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NOAA Technical Report NMFS CIRC-391

Calanoid Copepods of the Genera *Spinocalanus* and *Mimocalanus* from the Central Arctic Ocean, with a Review of the Spinocalanidae

DAVID M. DAMKAER

SEATTLE, WA
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CALANOID COPEPODS OF THE GENERA *SPINOCALANUS* AND *MIMOCALANUS* FROM THE CENTRAL ARCTIC OCEAN, WITH A REVIEW OF THE SPINOCALANIDAE

DAVID M. DAMKAER[1]

ABSTRACT

The family Spinocalanidae includes small to medium-sized marine calanoid copepods belonging to the genera *Spinocalanus, Monacilla, Mimocalanus,* and *Teneriforma.* All species are deep-living and often comprise a large proportion, or even a majority, of the copepods in deep samples. In spite of their prevalence, definitive knowledge of the Spinocalanidae has lagged behind that of other copepod groups because adequate collections from deep water have been few, and specimens from widely separated localities have seldom been compared. Most important, however, is the fact that the fragility of the specimens makes them very difficult to study; most investigators attempting to describe or identify Spinocalanidae have indicated that their specimens were damaged and incomplete.

The present study is based on collections of zooplankton from Fletcher's Ice Island, T-3, in the Canadian Basin of the Arctic Ocean in 1967-68. The seven specics of Spinocalanidae from these collections are redescribed, and their vertical distributions are discussed, based on series of samples from discrete depth intervals to 3,000 m.

The systematics of the Spinocalanidae has been reconsidered, using characters in addition to those most commonly lost in sampling. All published descriptions and records are discussed. Several critical type specimens and specimens forming the bases of widespread records have been examined and are redescribed. Keys to the genera and all of thc species have been prepared, with the goal of enabling an investigator to identify even damaged specimens. Many named species or forms have been placed in synonymy, and two new species (*Spinocalanus terranovae* and *Mimocalanus heronae)* are described. The family is now considered to comprise 32 species, distributed as follows: *Spinocalanus* (19), *Monacilla* (4), *Mimocalanus* (8), and *Teneriforma* (1).

INTRODUCTION

The family Spinocalanidae includes small to medium-sized marine calanoid copepods belonging to the genera *Spinocalanus* (42 named species or forms), *Monacilla* (8), *Mimocalanus* (8), and *Teneriforma* (1). The Spinocalanidae have been difficult to study because they are prone to damage in sampling, resulting typically in the loss of the first antennae and most swimming legs. Grice and Hulsemann (1965) said that "the identification of species of *Spinocalanus* was difficult as almost all the specimens examined were damaged . . . . This appears to be the case for other collections also because most previous descriptions are accompanied by few illustrations . . . . Most of the species in this genus need to be restudied and redescribed, a task which will be difficult unless specimens in better condition than the present ones can be obtained." This fragility and rather generalized body form have given the Spinocalanidae a potential to be overlooked or ignored in surveys of deep-living copepods, even though they often comprise a large proportion, or even a majority, of the copepods in deep samples. Also, as in many other calanoids, adult males are scarce. Johnson (1963a), in discussing this group, said that "the clarification of the position of these males and the whole complex of *Spinocalanus* species requires additional material and much more thorough study."

Definitive knowledge of the Spinocalanidae has also lagged behind that of other copepod groups because the species are mostly deep-living; adequate collections have been few, and specimens from widely separated localities have seldom been compared. Most have been collected by towing plankton nets vertically from great depths to the surface, so that depth limits of the species are difficult to define.

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Their absence from surface-layer samples, however, indirectly fixes their upper depth limit, generally at about 100 m. Spinocalanids have been collected in a lesser number of deep closing-net samples taken at discrete depths. A lower depth limit, if there is such a limit, has not been fixed; some species have an extraordinary vertical distribution, from 50 m to at least 5,000 m. The great vertical range gives these species a potential for wide, in some cases worldwide, distribution in the relatively uniform and interconnected deep-ocean water masses. The lack of records for some species from entire oceans cannot yet be accepted as an indication of real absence. In particular, the apparent bipolar distribution of *Spinocalanus antarcticus* should be reconsidered, to determine its distribution into lower latitudes.

In the decades since World War II interest in the Arctic Ocean has greatly increased, for commercial, strategic, and scientific reasons. The heroic days of the earliest Arctic explorations, when observations were gained under the harshest conditions, are past. In spite of the difficult and distant environment, information now accumulates relatively rapidly. The development of air transportation and the use of floating ice platforms have made all Arctic areas accessible throughout the year. Still, most subjects of investigation remain in an exploratory stage; this is especially true of the oceanic plankton of the high polar basins. The oceanic copepods, the most numerous of the net-zooplankton, are the subject of less than a dozen published reports, and only three or four of these consider deepwater species. The present study is based on collections of zooplankton from Fletcher's Ice Island, in the Canadian Basin in 1967-68. The spinocalanids from these collections are redescribed, and their vertical distributions are discussed.

The systematics of the Spinocalanidae has been reconsidered using characters in addition to those usually considered, the antennae and legs. Many named species are placed in synonymy, and two new species are described. The family is now considered to comprise 32 species, distributed as follows: *Spinocalanus* (19), *Monacilla* (4), *Mimocalanus* (8), and *Teneriforma* (1). Keys to all the species have been prepared, with the goal of enabling an investigator to identify even damaged specimens.

Field Methods

The sampling base for the Arctic collections was Fletcher's Ice Island, also called "T-3." T-3 is a tabular ice sheet ca. 8 × 13 km and 30 m thick, fragmented from northern Ellesmere Island. T-3 is caught up in the pack ice, with which it drifts at about 2-4 km/day. At the time the material to be described was collected, T-3 was in the Canadian Basin, ranging in latitude from 79°30′N to 85°N and in longitude from 142°W to 175°W (Figs. 1, 2). Positions were determined only every few days. Mohr (1959) and Schindler (1968) have summarized the history and use of the ice island.

Zooplankton samples were collected through a hole in the sea ice (3-4 m thick) bordering the island. A small prefabricated plywood hut was assembled over the hole; the hut housed a winch, with 4,000 m of hydrographic wire, powered by a 5-hp gasoline engine. The wire ran through a meter wheel attached to a 2-m tripod placed over the hole; a 50-kg weight was secured to the end of the wire.

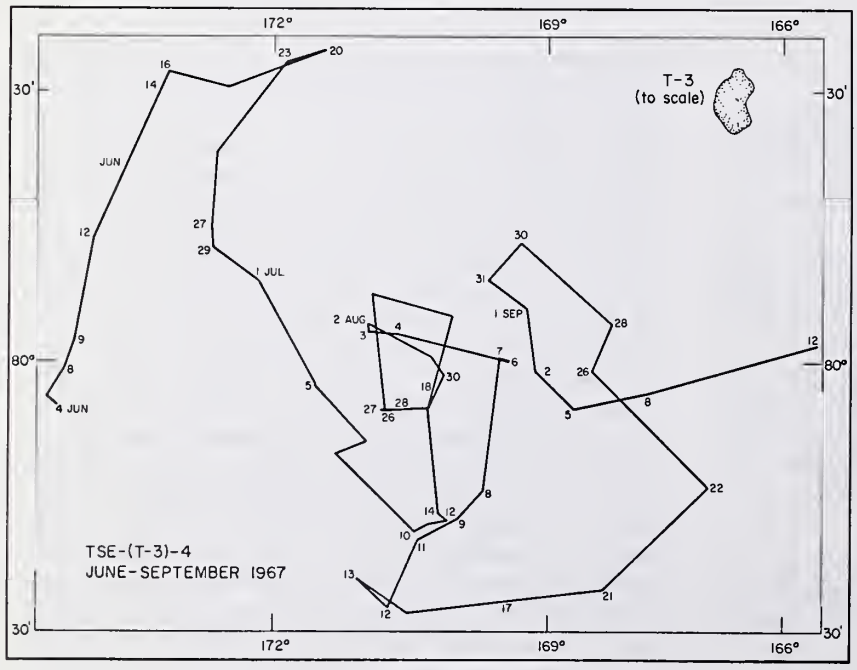


Figure 1.—Positions and track of Fletcher's Ice Island ("T-3") in the Canadian Basin, June-September 1967.

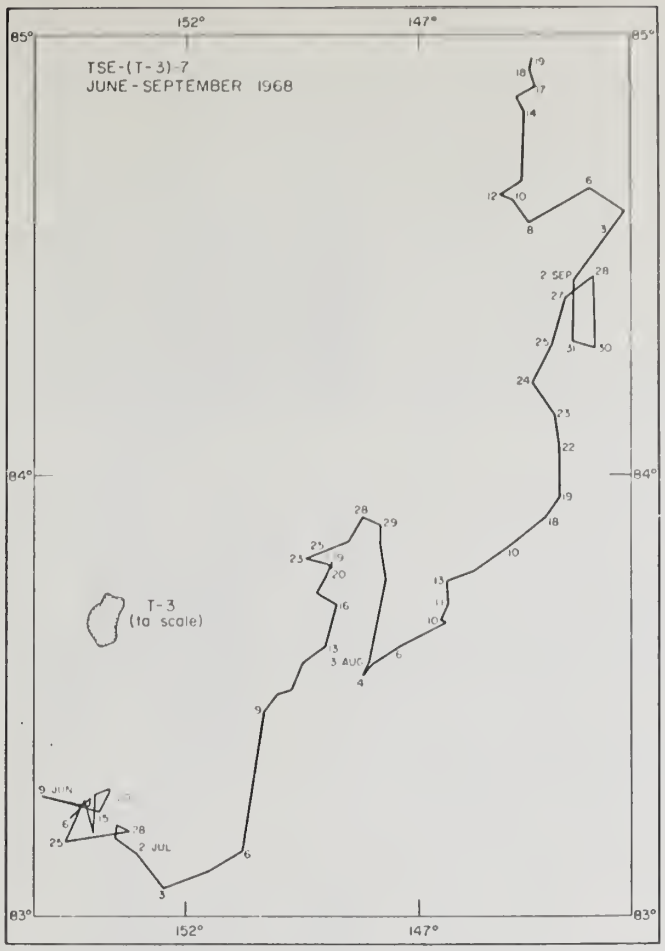


Figure 2.—Positions and track of Fletcher's Ice Island ("T-3") in the Canadian Basin, June-September 1968.

Samples were collected in 1-m closing nets with mesh apertures of 0.215 mm (1967) and 0.110 mm (1968). A series of vertical samples was obtained in summer 1967 (July and September), and a second series in summer 1968 (June, July, and August), a total of 142 samples. Depth intervals sampled were: 10-100 m, 10-m intervals; 100-200 m, 20-m intervals; 200-400 m, 50-m intervals; 400-500 m, 100-m intervals; 500-3,000 m, 500-m intervals. Usually more than one sample was obtained from each interval each summer. Some specimens were obtained from samples not in the above routine series; these samples are included in Table 1, but the specimens are not enumerated in Table 2.

Samples were fixed in 5% formaldehyde/seawater solution, buffered with sodium borate.

Table 1.—Source of Arctic specimens.

Sample	Program Sample	Date	Depth (m)
A1	573	12 VII 67	900-1,000
A2	846	8 IX 67	700-800
A3	847	8 IX 67	900-1,000
A4	848	8 IX 67	900-1,000
A5	850	9 IX 67	700-800
A6	851	10 IX 67	600-700
A7	0	5 V 68	400-500
A8	60	10 VI 68	500-1,000
A9	61	10 VI 68	400-500
A10	62	10 VI 68	350-400
A11	63	10 VI 68	300-350
A12	64	10 VI 68	250-300
A13	80	12 VI 68	500-1,000
A14	81	12 VI 68	400-500
A15	120	14 VI 68	400-500
A16	121	14 VI 68	500-1,000
A17	122	24 VI 68	2,500-3,000
A18	123	24 VI 68	2,000-2,500
A19	124	24 VI 68	1,500-2,000
A20	125	24 VI 68	1,000-1,500
A21	126	24 VI 68	500-1,000
A22	127	24 VI 68	400-500
A23	167	7 VII 68	500-1,000
A24	168	7 VII 68	1,000-1,500
A25	169	7 VII 68	1,500-2,000
A26	170	7 VII 68	1,990-2,500
A27	212	19 VII 68	500-1,000
A28	213	19 VII 68	1,000-1,500
A29	214	19 VII 68	1,500-2,000
A30	215	19 VII 68	2,000-2,500
A31	216	26 VII 68	2,000-2,500
A32	217	26 VII 68	1,500-2,000
A33	218	26 VII 68	1,000-1,500
A34	219	26 VII 68	500-1,000
A35	220	26 VII 68	400-500
A36	282	7 VIII 68	500-1,000
A37	283	7 VIII 68	1,000-1,500
A38	284	7 VIII 68	1,500-2,000
A39	285	7 VIII 68	2,000-2,500
A40	286	13 VIII 68	1,500-2,000
A41	287	13 VIII 68	1,000-1,500
A42	288	13 VIII 68	500-1,000
A43	289	13 VIII 68	400-500
A44	309	20 VIII 68	1,500-2,000
A45	310	21 VIII 68	1,000-1,500
A46	311	21 VIII 68	500-1,000
A47	2272	26 VIII 68	1,000-1,500
A48	3005	5 VIII 68	2,000-2,500
A49	3006	5 VIII 68	1,500-2,000
A50	3063	24 VIII 68	2,000-2,500
A51	3076	14 VIII 68	2,000-2,500
A52	3090	18 VIII 68	1,500-2,000

Laboratory Methods

Arctic specimens were preserved in 4% formaldehyde/3% sodium acetate solution; most borrowed specimens were preserved in ethyl alcohol. Gross observations and drawings were made in water or water/glycerine solution, to and from which the specimens were moved slowly through series of solutions. Dissected specimens were stained overnight in methyl blue/lactic acid solution; detached appendages were oriented, drawn (usually without cover slips), mounted in glycerine under 9-mm diameter cover slips and sealed with a heavy ring of nail-polish lacquer. Usually

Table 2.—Estimated numbers of Arctic Spinocalanidae from 24 depth intervals; a number followed by "-0" indicates the number of negative samples; "+" indicates less than 0.1/10 m; F = female, M = male, J = juvenile.

Depth (m)	Samples	*Spinocalanus longicornis*		*Spinocalanus antarcticus*		*Spinocalanus horridus*		*Spinocalanus elongatus*	
		Number/sample	Average/ 10 m	Number/sample	Average/ 10 m	Number/sample	Average/ 10 m	Number/sample	Average/ 10 m
10-20	5	5-0	0	5-0	0	5-0	0	5-0	0
20-30	5	5-0	0	5-0	0	5-0	0	5-0	0
30-40	4	4-0	0	4-0	0	4-0	0	4-0	0
40-50	5	5-0	0	5-0	0	5-0	0	5-0	0
50-60	7	7-0	0	7-0	0	7-0	0	7-0	0
60-70	7	7-0	0	7-0	0	7-0	0	7-0	0
70-80	7	7-0	0	7-0	0	7-0	0	7-0	0
80-90	5	3-0; 5J; 3J	1.6	5-0	0	5-0	0	5-0	0
90-100	5	2-0; 10F; 1M; 20J	6.2	5-0	0	5-0	0	5-0	0
100-120	5	1-0; 80F, 40J; 12F, 2J; 4J; 1J	14	5-0	0	5-0	0	5-0	0
120-140	5	60F, 120J; 13F, 10J; 3J; 3J; 2J	21	5-0	0	5-0	0	5-0	0
140-160	5	30F, 45J; 12F, 20J; 6F, 18J; 10J; 4J	14	3-0; 45J; 2J	4.7	5-0	0	5-0	0
160-180	5	25F, 45J; 10F, 35J; 50J; 40J; 3J	21	5-0	0	5-0	0	5-0	0
180-200	5	40F, 160J; 30J; 22J; 20J; 10J	28	4-0; 660J	66	5-0	0	5-0	0
200-250	5	15F, 15M, 180J; 200J; 120J; 110J; 80J	29	2-0; 15F; 360J; 40J	17	5-0	0	5-0	0
250-300	6	45F, 45J; 30F, 70J; 20F, 200J; 13F; 60J; 30J	17	2-0; 345J; 75J; 60J; 11J	16	6-0	0	6-0	0
300-350	6	1-0; 15F, 135J; 10F, 60J; 1M, 78J; 30J; 15J	11	3-0; 10F, 190J; 60J; 32J	9.7	6-0	0	3-0; 20J; 15J; 5J	1.3
350-400	6	1-0; 10F, 30J; 10F, 25J; 5F, 100J; 2F, 9J; 35J	7.5	3-0; 39F, 5M, 138J; 5F, 25J; 20J	7.6	6-0	0	5-0; 5M	0.2
400-500	8	1-0; 15F, 4M, 1J; 15F, 45J; 14F, 2M; 9F, 5M; 6F, 12J; 5F, 3M; 1F, 3M	1.8	5-0; 20F, 15J; 2F, 1M; 5J	0.5	8-0	0	7-0; 1F	+
500-1,000	10	2-0; 69F, 9M; 45F, 5M; 27F, 1M; 23F, 2M; 22F, 4M; 13F; 10F; 9F, 2M	0.5	3-0; 58F, 12M, 13J; 53F, 6M, 5J; 33F, 4M, 2J; 16F, 1M, 5J; 14F, 1M, 1J; 12F, 3M; 8F, 1M	0.5	7-0; 1F, 1M; 1F; 1M	+	2-0; 3F, 6M, 5J; 2F, 3M, 6J; 2F, 3M; 2F, 1J; 1F, 3M; 1F, 3M; 3M; 2M	0.1
1,000-1,500	8	4-0; 19F; 3F; 2F; 1F	+	1-0; 12F, 1J; 12F; 9F, 4J; 7F; 5F; 2F; 1F, 1J	0.1	1-0; 4F; 3F, 1M; 3F, 1J; 3F; 2F; 1F, 1J; 1M	+	48F, 3M; 39F, 4M; 38F, 10M; 18F, 5M; 15F, 1M; 7F, 2M; 6F; 3F, 2M	0.5
1,500-2,000	9	7-0; 7F, 1M; 5F	+	4-0; 10F; 8F, 1J; 4F; 2F, 1M; 2F	+	6-0; 7F, 1J; 2F; 1F	+	718F, 3M; 61F; 60F, 1M; 32F; 12F; 11F; 9F; 8F, 1M, 1J; 8F	2.1
2,000-2,500	8	4-0; 15F, 3M; 15F, 3M; 5F; 1F	+	2-0; 25F, 2M; 7F; 4F, 1M; 1F; 1F; 1F	0.1	7-0; 3F, 2M	+	578F; 516F; 345F, 2M; 36F; 28F; 21F; 10F; 3F	3.8
2,500-3,000	1	1-0	0	1-0	0	1-0	0	1-0	0

Table 2.—Continued.

Depth (m)	Samples	*Spinocalanus polaris*		*Mimocalanus crassus*		*Mimocalanus sulcifrons*	
		Number/sample	Average/ 10 m	Number/sample	Average/ 10 m	Number/sample	Average/ 10 m
10-20	5	5-0	0	5-0	0	5-0	0
20-30	5	5-0	0	5-0	0	5-0	0
30-40	4	4-0	0	4-0	0	4-0	0
40-50	5	5-0	0	5-0	0	5-0	0
50-60	7	7-0	0	7-0	0	7-0	0
60-70	7	7-0	0	7-0	0	7-0	0
70-80	7	7-0	0	7-0	0	7-0	0
80-90	5	5-0	0	5-0	0	5-0	0
90-100	5	5-0	0	5-0	0	5-0	0
100-120	5	5-0	0	5-0	0	4-0; 2J	0.2
120-140	5	5-0	0	5-0	0	5-0	0
140-160	5	5-0	0	5-0	0	5-0	0
160-180	5	5-0	0	5-0	0	5-0	0
180-200	5	5-0	0	5-0	0	5-0	0
200-250	5	5-0	0	5-0	0	4-0; 10J	0.4
250-300	6	6-0	0	6-0	0	5-0; 30J	1.0
300-350	6	6-0	0	6-0	0	4-0; 15J; 5J	0.7
350-400	6	6-0	0	6-0	0	5-0; 20F	0.7
400-500	8	8-0	0	7-0; 1J	+	8-0	0
500-1,000	10	10-0	0	5-0; 15F; 5F; 2F, 2J; 1F; 1J	+	10-0	0
1,000-1,500	8	8-0	0	3-0; 2F, 1J; 2F; 1F; 1F; 1J	+	8-0	0
1,500-2,000	9	5-0; 160F, 1M; 7F, 2M; 4F; 4F	0.4	1-0; 94F, 8M, 1J; 6F; 5F; 4F, 1M; 2F; 1F; 1F; 2M	0.3	8-0; 2F, 5J	+
2,000-2,500	8	381F, 20M; 352F, 32M; 345F, 38M; 41F, 2M; 29F, 1M; 28F, 1M; 9F; 8F	3.2	1-0; 114F, 1M; 93F, 1M; 79F; 16F, 1M; 5F; 3F; 2F, 1M	0.8	4-0; 3F, 1J; 3F; 2F, 2M, 1J; 1F, 3M	+
2,500-3,000	1	15F, 1M	0.3	1-0	0	1-0	0

seven cover slips were used for appendages from one specimen in standard groups on one microscope slide. Slides carefully sealed have endured without noticeable change for 2 yr.

Body length was measured from the anterior border of the prosome to the posterior edge of the caudal rami.

All figures were drawn with the aid of a Wild M20 drawing tube. Unless otherwise stated, illustrated specimens are from Arctic collections. Except for a few figures of the left swimming legs and one of the left first maxilla gnathobase, all illustrated appendages are from the specimen's right side. First antennae are shown in ventral view. Maxillipeds are shown in anterior view. All other appendages are shown in posterior view. The letter after each figure legend refers to the 0.1-mm scale to which the figure was drawn (Fig. 225).

Counts of Arctic spinocalanids from below 500 m are from entire samples; most estimates of total specimens from above 500 m are based on counts from subsamples, one-half to one-twentieth of whole samples (Table 2). Many specimens were enumerated, but only the relatively few specimens in good condition were examined for descriptive purposes (Table 1 and lists of specimens studied).

Material Studied

During the systematic study of Arctic spinocalanids it was necessary to obtain specimens from other collections for comparison and for supplementing published descriptions. An effort was made to examine a maximum number of critical type specimens and specimens on which widespread records are based. Arctic specimens of the present collection are listed in Table 1 and borrowed specimens are listed in Table 3. Locations for samples from dates listed in Table 1 can be interpolated from Figures 1, 2; the sample from 5 May 1968 was taken at about lat. 82°19′N, long. 158°16′W.

Abbreviations used in the descriptions are listed below:

Ce	cephalosome; head region including the somite of the maxillipeds
Th1-Th5	somites of legs 1-5
A1-A2	antennae 1-2
Mn	mandible
Mx1-Mx2	maxillae 1-2
Mxp	maxilliped
P1-P5	legs 1-5
B1-B2	basipod segments 1-2

Table 3.—Sources of borrowed specimens.

Sample	Source	Program, station	Location	Date	Depth (m)	Catalog number
1.	BM	RESEARCH	Bay of Biscay	00		1926.12.6.125-127
2.	BM	Farran	off Mayo	06	900	1911.11.8.37514-518
3.	BM	Farran	off Mayo	06	1,260	1911.11.8.37508-513
4.	BM	Farran SR470	56°16′N, 11°27′W	26 VIII 07	720-900	1908.7.6.5
5.	BM	Farran	W. of Ireland	09		1911.11.8.37492-499
6.	BM	TERRA NOVA-172	66°38′S, 178°47′W	10 XII 10	0-400	1930.1.1.293-404
7.	BM	TERRA NOVA-270 or 282	66°30′-76°S, ca. 165°W	10	0-1,000	1930.1.1.405-414
8.	NZOI	A452	75°35′S,173°18′W	12 I 59	0-1,300	
9.	NZOI	A453	75°09′S,171°00′W	13 I 59	0-1,000	
10.	NZOI	A455	74°22′S,178°35′W	15 I 59	0-300	
11.	NZOI	A459	75°17′S,172°20′E	16 I 59	0-500	
12.	NZOI	A462	71°15′S,176°30′E	20 I 59	0-1,000	
13.	NZOI	F945	31°20′S,165°19′E	22 X 68	500-1,000	
14.	NZOI	F946	34°32′S,157°32′E	3 XI 68	0-1,000	
15.	OSLO	NORTH POLAR	81°27′N,ca.123°E	22 V 94	100	F2481, F2550, F6511
16.	OSLO	Sars, Osterfjord	60°45′N, 5°15′E	ca. 1900	400-600	F7847
17.	OSLO	Sars, Osterfjord	60°45′N, 5°15′E	ca. 1900	400-600	F7850
18.	OSLO	Sars, Osterfjord	60°45′N, 5°15′E	ca. 1900	400-600	F4923a
19.	OSLO	Sars, Osterfjord	60°45′N, 5°15′E	ca. 1900	200-400	
20.	OSLO	Sars, Osterfjord	60°45′N, 5°15′E	ca. 1900	400-600	F7848-F7849
21.	OSLO	Sars, Ørsten	62°10′N, 6°10′E	ca. 1900	200-1,000	
22.	OSLO	MICHAEL SARS-4	49°38′N, 11°35′W	11 IV 10		
23.	OSLO	MICHAEL SARS-34	28°52′N, 14°16′W	14 V 10		
24.	SIO	CCOFI5206-90.28D	33°28′N,117°47′W	13 VI 52	300	XVIII-775
25.	SIO	CCOFI5504-120.50	27°34′N,115°39′W	12 IV 55	0-140	XVIII-785
26.	SIO	NORPAC-33Cl	41°45′N,124°29′W	6 VIII 55	0-140	XVIII-777
27.	SIO	EASTROPAC-H41	4°03′N, 81°45′W	12 XI 55	0-300	XVIII-1788
28.	SIO	CCOFI5804-137.30	25°14′N,112°44′W	4 IV 58	0-140	XVIII-776
29.	SIO	CCOFI5804-137.40	24°55′N,113°24′W	4 IV 58	0-140	XVIII-1801
30.	SIO	TETHYS-7	13°13′N,127°06′W	23 VI 60	0-1,000	
31.	SIO	TETHYS-12	1°45′S,133°44′W	29 VI 60	0-1,000	

Re	exopod
Ri	endopod
Re1, etc.	exopod segments
Ri1, etc.	endopod segments

The prosome of most spinocalanids is fragile; many specimens are broken between Th1 and Th3. There is also a tendency for the Ce ventrolateral margin to curl outward (see *Spinocalanus usitatus).* The sutures between Ce and Th1 and Th4 and Th5, are clear on most females. Sometimes, as with *S. magnus,* the specimen must be cleared in glycerine to trace the unbroken suture; this suture is more easily seen in unstained material.

The caudal setae are extremely fragile, and in some species have probably never been seen intact. Usually the caudal setae are represented by short broken bases, and even the bases may be missing.

All appendages are fragile. Probably most damage is caused by the net in sampling; if the loss of appendages were due to the fixative, great numbers of detached appendages would be found in the samples, and such is not the case. Some damages probably occur naturally, and the frequent abnormalities of the swimming legs are probably due to these damages (see below).

A1 of females is most often broken, usually at a suture distal to segment 12. This appendage is intact, however, on most males, where the segments beyond 10 are more or less fused. Certain extraordinarily large setae on A1 are nearly always broken at the base. Esthetes are fragile and usually only indicated by their short bases.

In the A1 armature (Table 4) there are probably no specific differences between females of *Spinocalanus* and *Mimocalanus* (except perhaps in *S. antarcticus* and *S. magnus*: segment 15 with only 1 seta). In males, only segment 14 separates *Mimocalanus* and *Spinocalanus* species; 18 other segments have equivalent armature; 6 other segments show specific differences, and therefore do not *consistently* separate the 2 genera (segment 8 could never separate the genera).

A1 armature could not be completely verified for all species, since some specimens had only partial or no A1. Apparent deviations from Table 4 are noted and should be reexamined at each opportunity. These apparent deviations, except in the two species noted

Table 3.—Continued.

Sample	Source	Program, station	Location	Date	Depth (m)	Catalog number
32.	SIO	CCOFI6106-120.45	27°42′N,115°35′W	15 VI 61	300	XVIII-778, 779, 782
33.	SIO	CCOFI6106-120.50	27°33′N,115°50′W	17 VI 61	400	XVIII-788
34.	SIO	CCOFI6106-120.60	27°30′N,116°31′W	13 VI 61	400	XVIII-787
35.	SOSC	IPHC-235C	56°31′N,136°00′W	2 III 30	700-900	
36.	SOSC	IPHC-410E	55°45′N,149°50′W	30 V 31	1,300-1,500	
37.	SOSC	IPHC-429E	55°25′N,141°12′W	7 VI 31	1,300-1,500	
38.	USC	TENCATI-155	79°42′N,170°00′W	9 VIII 67	1,000	
39.	USNM	ALBATROSS-5120	13°46′N,120°30′E	21 I 08	0-630	74126
40.	USNM	ALBATROSS-5246	6°29′N,126°19′E	15 V 08	0-180	74125
41.	USNM	CARNEGIE-87	18°05′S,145°33′W	11 III 29	100	
		and/or 152	10°05′N,139°44′W	27 X 29	100	
42.	USNM	ANTON BRUUN-338	2°38′S, 65°01′E	29 V 64	1,000-2,000	113514
43.	USNM	ANTON BRUUN-349	26°03′S, 64°58′E	25 VI 64	1,000-2,000	113513
44.	USNM	ANTON BRUUN-351B	29°45′S, 64°58′E	28 VI 64	350-1,710	113512
45.	USNM	TRIDENT-36CB5	24°33′N, 69°30′W	8 X 66	2,000-4,000	122646
46.	USNM	Ellesmere Island	ca. 83°N, 74°W	15 VI 67	0-285	122224
47.	USNM	ATLANTIS II-10	36°01′N, 17°16′E	20 V 69	1,000-1,150	136818
48.	WHOI	DISCOVERY II-3668	32°29′N, 20°09′W	19 III 58	3,000-4,000	1334
49.	WHOI	DISCOVERY II-4768	40°04′N, 19°57′W	12 X 61	2,000-2,800	1419
50.	WHOI	ANTON BRUUN-108	13°50′N, 70°07′E	25 V 63	1,000-2,000	1890
51.	WHOI	ANTON BRUUN-347	22°06′S, 64°55′E	23 VI 64	1,000-2,000	2394
52.	WHOI	ANTON BRUUN-349	26°03′S, 64°58′E	25 VI 64	1,000-2,000	2798
53.	WHOI	CHAIN 60-1	11°03′N, 78°43′W	3 VI 66	505-1,000	
54.	WHOI USNM	CHAIN 60-1	11°03′N, 78°43′W	3 VI 66	1,004-1,850	123780, 123784
55.	WHOI USNM	CHAIN 60-2	19°02′N, 81°57′W	9 VI 66	487-950	123771, 123783, 123785
56.	WHOI	CHAIN 60-2	19°02′N, 81°57′W	9 VI 66	980-1,900	
57.	WHOI	CHAIN 60-4	21°55′N, 95°26′W	18 VI 66	203-500	
58.	WHOI	CHAIN 60-4	21°55′N, 95°26′W	18 VI 66	500-1,000	
59.	WHOI	CHAIN 60-4	21°55′N, 95°26′W	18 VI 66	1,003-1,900	
60.	UW	THOMPSON	50°00′N,145°00′W	6 VIII 73	330-385	

Table 4.—*Spinocalanus* and *Mimocalanus*, A1 armature.

Genus; sex	A1 segments[1]																								
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV
Spinocalanus, *Mimocalanus*; Female	3s	6s 1e	2s	2s	2s 1e	2s	2s	2s	2s 1e	1s	2s	2s 1e	1s	2s 1e	2s	2s	2s	2s	2s 1e	1s	1s	2s	2s	2s	5s 1e
Spinocalanus; Male	1s 1e	6s 4e	2s 2e	2s 1e or 2s 2e	2s 2e	2s 1e	2s 2e	2s 1e or 2s 2e	2s 2e	1s 1e	2s 1e	2s 1e	1s 1e	2s 1e	1s 1e or 2s 1e	1s 1e	1s 1e	1s 1e	1s 1e or 2s 1e	(1) 0 or 1s (2) 1s or 1e	1s 1e	2s 1e	2s 1e	2s	5s 1e
Mimocalanus; Male	1s 1e	6s 4e	2s 2e	2s 1e	2s 2e	2s 1e	2s 2e	2s 1e or 2s 2e	2s 2e	1s 1e	1s 1e or 2s 1e	2s 1e	1s 1e	1s 1e	1s 1e	1s 1e	1s 1e	1s 1e	1s 1e	rt 0 and lt 1e	1s 1e	2s 1e	2s 1e	2s	5s 1e
Males, genera equivalent	*	*	*		*	*	*		*	*		*	*			*	*	*			*	*	*	*	*
Males, genera differ														*											
Males, species differ				*				*			*				*				*	*					

[1]s = seta; e = esthete; side (1) may be right (rt) or left (lt), side (2) is the remaining side.

above, occurred only in female segment 1, which is easily damaged during dissection.

There are slight specific differences in A1 between some *Spinocalanus* males, especially in relation to the merging of segment 20 to 21, which occurs on *either* the left *or* the right side, depending on the species (see Figs. 29 and 59). The merged, and apparently "lost," segment 20 may or may not be represented by 1 seta, but never by an esthete. If there is no seta on the "lost" segment 20, the complete and distinct segment 20 on the opposite A1 bears either 1 seta or 1 esthete. If there is 1 seta on the "lost" segment 20, the complete segment 20 on the opposite A1 bears 1 esthete. Other specific differences are noted in the descriptions. In Table 4 and the discussion of deviations, Roman numerals are A1 segments; Arabic numerals are numbers of setae (s) and numbers of esthetes (e). The armature of segment 2 in females is distributed as follows (see Fig. 13): proximal, 2 setae; midlength, 2 setae, 1 esthete; distal, 2 setae. The armature of segment 2 in males is distributed as follows (see Fig. 29): proximal, 2 setae, 1 esthete; midlength, 2 setae, 2 esthetes; distal, 2 setae, 1 esthete. In addition to anterior armature, segments 22-24 have 1 posterior seta; segment 25 has 1 posterior and 2 terminal setae. Esthetes are only on the anterior edge, somewhat ventral to setae.

Not enough material of *Monacilla* and *Teneriforma* was available to warrant generalizations for A1 armature; published information is also insufficient.

A2 usually is unbroken, although some setae may detach. In dissecting it is difficult not to detach these setae, both while cutting the appendage and while untangling it from the remaining appendages.

Mn palp has very long setae, especially on Re, and these are easily broken while removing the appendage. The blade is "capped" by thin, extremely fragile teeth. The main body of the blade, which is much stronger, has a foundation of "teeth," but the actual biting surfaces are the fragile "caps." The 90° twist of the Mn blade requires that the blade itself be cut across at about half its length, so that it will lie flat when mounted, but successful cutting is difficult because of the fragile teeth.

Mx1 setae are long and fragile. The female gnathobase is strong and seldom damaged.

Mx2 has some very small setae which are difficult to see in all preparations, although most setae are strong and not too fragile. The outer seta, if present, is undoubtedly very fragile and was intact on only a few specimens.

Mxp usually is present and provides important characters. Some of the armature is fragile, however, especially B1-2 transverse spine-combs, if present, and the Ri4-5 outer setae in most species.

The fragility of the swimming legs has held back the study of the Spinocalanidae. Specimens usually have complete P1, but only infrequently P2, and specimens with P3 or P4 are rarities. Ri are less often detached than Re, so that if there are a few specimens of a

species in a sample, the probability is high that there will be P2 Ri or even P3 Ri. Usually the rami are detached between Re1-2 and Ri1-2.

The setae of the swimming legs are also fragile, and usually broken at their own joints which occur at about two-fifths the length of the seta.

Spinocalanus and *Monacilla* species have strongly developed rows of spines and spinules on the surface (especially the posterior surface) of certain segments in the swimming legs. These spines are also rather fragile and are sometimes detached, usually leaving small scars. Sometimes a spine becomes detached while the appendage is being mounted on a slide, and the spine may lie in an unnatural position. The position, size, and shape of these spines and spine rows are rather constant within species, but there is some variability, especially in groups of smaller spines, spinules, or denticles. Sometimes there are slight differences between right and left legs in the same specimen, generally involving only a numerical difference in one or a few spines.

About 10% of the specimens examined had actual abnormalities of the swimming legs: a typical seta instead of the modified sawlike terminal seta; a short Re3 with a terminal arc of typical setae; loss of one or more outer spines (Fig. 207); or an extra seta. The other leg of the pair is usually typical, and both should be examined. Certain of these abnormalities could arise, if the fragile appendage is broken in a late juvenile stage and does not develop normally in time for the adult stage.

Male P5 are usually not detached, although some species have relatively long and fragile rami. In this study, males with left B1 longer than right B1 are termed "left-handed"; conversely, "right-handed" males have right B1 longer than left B1. Handedness appears to be species-specific, and is also correlated with the merging of segment 20 to 21 in the opposite A1.

The most important diagnostic characteristics of the family and genera are in italics in the descriptions. The species within each genus are numbered and discussed in chronological order, including junior synonyms which are placed in parentheses.

THE ARCTIC SPINOCALANIDAE

Arctic Hydrography

Coachman (1963) has reviewed the hydrography of the Arctic Ocean. In general, there are three layers (Fig. 3), based primarily on temperature and secondarily on salinity: (1) Arctic Water, from the surface to about 200 m, (2) Atlantic Water, from 200 to 900 m, and (3) Arctic Bottom Water, from 900 m to the bottom (maximum depth, over 5,000 m).

The uppermost layer, the Arctic Water, is itself composed of three layers: (1) surface, 0-25 or 50 m; (2) subsurface, to 100 m; and (3) lower Arctic Water. The surface layer is most responsive to local conditions; it is cold (varying seasonally from −1.85° to 0°C) and dilute (varies around 30‰), and usually well mixed. The subsurface layer shows increasing salinity (to about 33‰). The lower Arctic Water is transitional to Atlantic Water.

Freshwater, mainly from Eurasia, and low salinity water entering the Arctic from Bering Strait (sill depth about 100 m) form the Arctic Water. This layer, nearly 200 m thick, flows under the influence of the wind toward the basin exit between Spitsbergen and Greenland. Some Arctic Water also leaves through the channels between the Canadian Arctic Islands and Greenland, flowing into Baffin Bay and Davis Strait. There is a more or less closed clockwise movement of this layer in the Canadian Basin (Beaufort Sea), probably also a consequence of the wind pattern. The sampling platform, T-3, has been caught in this gyre.

Under the general surface outflow is a subsurface inflow of rather uniform Atlantic Water. This layer has been defined as the warmer water (up to 2°C) lying between the upper and lower 0°C isotherms, which occur at about 200 and 900 m. Most Atlantic Water enters the Arctic between Spitsbergen and Greenland (maximum sill depth 600-700 m, average 450-500 m) and flows eastward along the continental slope of the Eurasian Basin. There is little seasonal change in the temperature or salinity (about 35‰).

More than half of the volume of the Arctic Ocean is Arctic Bottom Water, characterized by low temperature (less than 0°C) and rather high salinity (nearly 35‰). Most of this water is probably formed during the winter in the Norwegian Sea. The Bottom Water in the Canadian Basin is slightly warmer than that in the Eurasian Basin, since the source of the former is at or above the level of the dividing ridge (about 1,300 m). The pattern of movement of the bottom water is unknown.

There are no really sharp boundaries between these simplified layers, especially at the far side of the Arctic Ocean, in the Beaufort Sea, where the Atlantic Water has had the maximum loss of its character and where water intrudes from the Pacific.

Vertical Distribution of Arctic Spinocalanidae

The low standing crop of phytoplankton in the Arctic Ocean is attributed to the low submarine light intensities; the photosynthetic production is probably the lowest of any comparable ocean area (English, 1963).

Most early work on Arctic plankton, with the exception of Nansen's Norwegian North Polar Expedition (1893-1896), was confined to sporadic, seasonal investigations of shallow waters of peripheral seas, especially in the Atlantic Sector, the Barents Sea, and

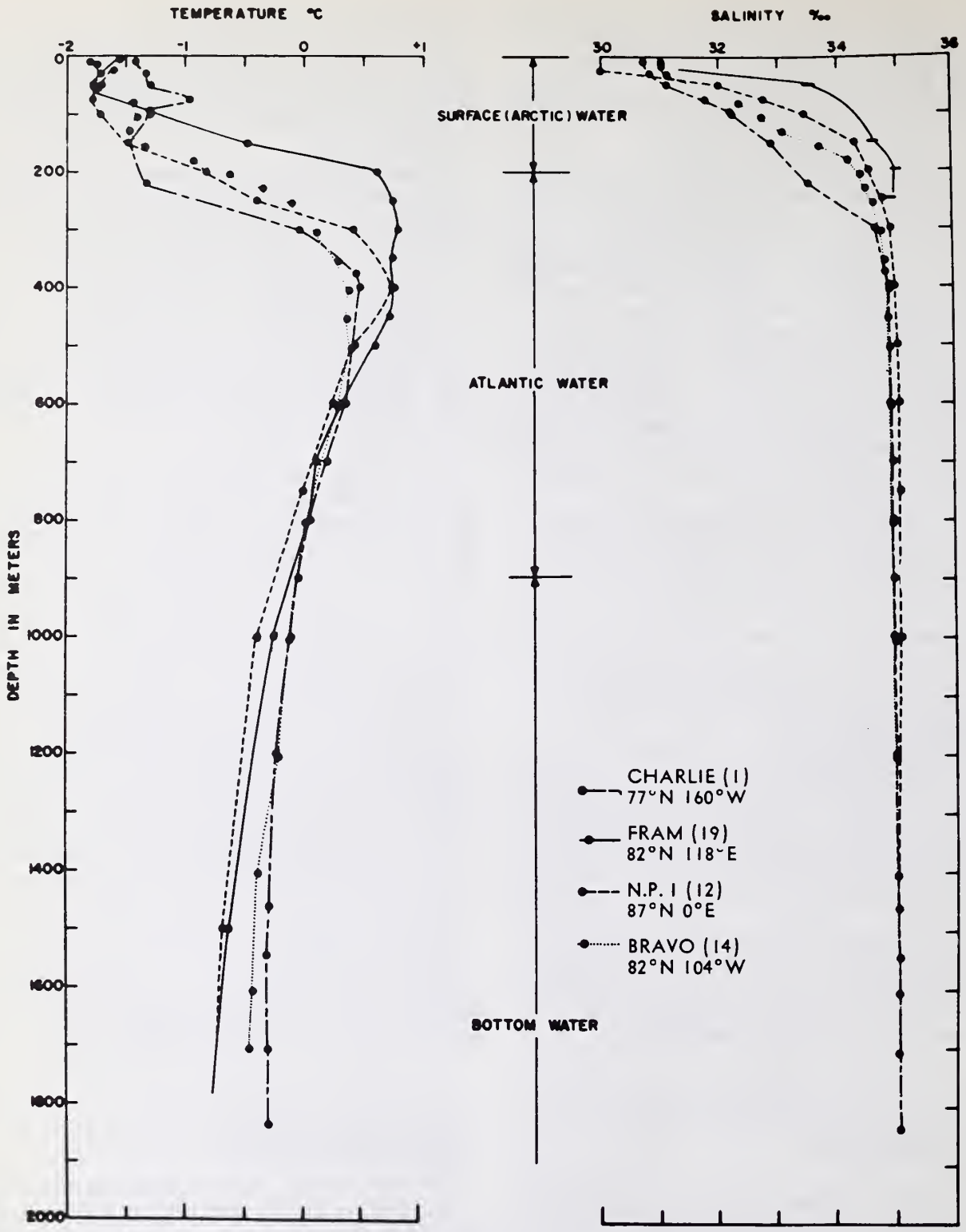


Figure 3.—Vertical distribution of temperature and salinity for four stations and the principal water masses of the central Arctic Ocean (from Coachman, 1963).

to a lesser degree, the Siberian Seas. Since World War II more attention has been given to the Beaufort and Chukchi Seas and, with the use of floating ice stations, the central Arctic.

Johnson (1963a, b) and Grainger (1965) have reviewed zooplankton investigations in the central Arctic. As in other oceans, the bulk of the net-plankton consists of crustaceans, with copepods predominating. The relative quantities of copepod species depend on the depth at the localities sampled, i.e., whether in shallow coastal seas or deep basins, and also on the depth of the sample. In shallow seas the most abundant species are *Pseudocalanus minutus* s. l., *Acartia longiremis,* and several species of *Oithona* and *Oncaea.* The predominant copepods in the surface layers of the deep basins are *Calanus glacialis, C. hyperboreus, Metridia longa, Microcalanus pygmaeus* s. l., *Paraeuchaeta glacialis,* and *Pseudocalanus minutus* s. l.

With increasing depth in the central basins other species become numerically more important, especially *Scaphocalanus magnus, Temorites brevis,* and *Spinocalanus* species. The number of species varies with depth, though the number of specimens decreases. About 30 species are found in the upper 300 m, nearly 50 from 300 to 1,000 m, and about 20 below 1,000 m.

Seven species of Spinocalanidae are reported from the Arctic samples of the present study: *Spinocalanus longicornis, S. antarcticus, S. horridus, S. elongatus, S. polaris, Mimocalanus crassus,* and *M. sulcifrons.* Numbers of each species in 142 samples from various depth intervals are given in Table 2. No differences in numbers of specimens or species of Spinocalanidae were attributed to differences in the mesh sizes of nets; the data from the 2 yr are not separated.

None of the samples from above 80 m contained Spinocalanidae.

Spinocalanus longicornis—The depth range of *S.longicornis* was 80-2,500 m. Adults were found from 90 to 2,500 m, juveniles from 80 to 500 m. The average concentration of total specimens was fairly uniform between 90 and 400 m, decreasing sharply above and below (Table 2).

Other Arctic workers (see systematic review) have included depths less than 80 m in the vertical range of *S. longicornis,* but most of these records are based on sampling intervals which included greater depths. Brodsky and Nikitin (1955) reported only one specimen in each of two samples from 25 to 50 m, and two specimens from 0 to 10 m, although the species was common below 50 m. The possibility of contamination in the 0-10 m sample should not be overlooked; many surface samples have been reported by other workers, and no other occurrences between 0 and 10 m have been noted. Brodsky (1957) reported *S. longicornis* in low numbers from 25 to 50 m, but indicated that it was not present from 0 to 10 m. Minoda (1967) reported a "very small number" of specimens, which were probably *S. longicornis,* from 0 to 50 m. Hughes (1968), in 399 samples collected with a plankton pump, from 5 to 185 m at 5-m intervals, found low numbers of *S. longicornis* in only one sample from each of the following depths: 25, 40, 55, 60, and 75 m.

Spinocalanus longicornis has been considered endemic to the Arctic, although in the present review it is reported from the Atlantic, including the Caribbean and Mediterranean, as well as from the Pacific, with a depth range of 50-2,700 m. *Spinocalanus longicornis* can be carried into the Atlantic in the Arctic Water; it can also be brought into the Arctic in the deeper Atlantic Water. Perhaps there is some limited exchange of *S. longicornis* in the near-surface water between the Pacific and Arctic.

Spinocalanus antarcticus—The depth range of *S. antarcticus* was 140-2,500 m. Adults were found from 200 to 2,500 m, juveniles from 140 to 2,000 m. The highest average concentration occurred between 180 and 300 m, with uniformly low numbers to 2,500 m (Table 2).

Reports of *S. antarcticus* are summarized in the following systematic review. Most records are based on sampling intervals which included depths below 140 m. Brodsky and Nikitin (1955) reported one female from 10 to 25 m. Johnson (1963a) found one female between 0 and 25 m. Dunbar and Harding (1968) reported few between 0-50 m and 50-100 m. Therefore its vertical range in the Arctic is at least 10-2,500 m, in low numbers in the Arctic Water and Arctic Bottom Water and in greatest numbers in the intermediate Atlantic Water. There would seem to be no physical barriers to its movement in and out of the Arctic. Its distribution into the Atlantic has not been noted, but the species occurs in the Pacific and Indian Sectors of the Antarctic (see systematic review).

Spinocalanus horridus—The depth range of *S. horridus* was 500-2,500 m. This species was found only in very low concentration (Table 2).

Reports of *S. horridus* are summarized in the following systematic review. Most records are based on very large vertical sampling intervals. Brodsky and Nikitin (1955) reported several females between 100 and 270 m and one male between 25 and 50 m; Minoda (1967) found one probable *S. horridus* between 0 and 200 m. These occurrences are rare; most records indicate an upper depth limit between 300 and 500 m.

Spinocalanus horridus can freely enter the Arctic in the Atlantic Water, and a few specimens are probably carried to the Atlantic in the Arctic Water. *Spinocalanus horridus* has a virtually worldwide distribution and a great vertical range everywhere.

Spinocalanus elongatus—The depth range of *S. elongatus* was 300-2,500 m. Adults were found from 350 to 2,500 m, juveniles from 300 to 2,000 m. The highest average concentrations occurred between 1,500 and 2,500 m, with uniformly low numbers up to 300 m (Table 2).

Brodsky (1957) reported that this species was found in low numbers from 25 to 200 m, but that it was the most numerous of all copepods between 800 and 3,000 m, where it comprised over 10% of the numbers of copepods. Dunbar and Harding (1968) reported no *S. elongatus* above 175 m, greatest numbers from 900 to 2,000 m, and none below 2,000 m.

Spinocalanus elongatus is apparently the only species of Spinocalanidae limited to the Arctic. Its rarity in the outflowing Arctic Water would definitely reduce its opportunities to enter the Atlantic. Possibly *S. elongatus* occurs in the North Atlantic in small numbers; it could be confused with the superficially similar *S. brevicaudatus,* found in the North Atlantic but apparently not in the Arctic.

Spinocalanus polaris—The depth range of *S. polaris* was 1,500-3,000 m. Only adults were found. The highest average concentration occurred between 2,000 and 2,500 m (Table 2).

Brodsky and Nikitin (1955) reported one juvenile *S. polaris* between 50 and 100 m and one female between 0 and 265 m, although most records place the bulk of this species below 1,000 m. *Spinocalanus polaris* is found in the North Atlantic, including the Caribbean, below 980 m; if it does not occur above 980 m, it could not be carried into the Arctic. However, the few Arctic *S. polaris* reported above 265 m provide a possibility for this species to be transported out of the Arctic.

Mimocalanus crassus—The depth range of *M. crassus* was 400-2,500 m, where it was found only in low concentration (Table 2). Only two other records of *M. crassus* are known: from the Caribbean Sea (Park, 1970) and the Indian Ocean (Grice and Hulsemann, 1967) with a vertical distribution similar to that found in the Arctic. *Mimocalanus crassus* has not yet been reported from the North Atlantic, but it probably occurs there at times, from where it could enter the Arctic in the Atlantic Water.

Mimocalanus sulcifrons—The depth range of *M. sulcifrons* was 100-2,500 m. Adults were found from 350 to 2,500 m, juveniles from 100 to 2,500 m, all in low concentration (Table 2).

Only a few other specimens of this species have been reported from the Arctic, in each case as *M. distinctocephalus.* Hughes (1968) found only juveniles, in two samples from 80 and 90 m. Other records are based on sample intervals of 0-2,000 m (Johnson, 1963a; Dunbar and Harding, 1968) and 0-520 m (Minoda, 1967). Johnson, and later Dunbar and Harding, in spite of the absence of this species in strictly near-surface samples, suggested that it is brought into the Arctic from the Pacific. However, *M. distinctocephalus* (= *M. nudus*) in the North Pacific has not been reported with certainty above 200 m (see systematic review); therefore, it probably can not enter the Arctic by this route. *Mimocalanus nudus* has not been reported from the Arctic.

Only a few specimens of *M. sulcifrons* have been reported from the North Atlantic, and only between 2,000 and 4,000 m. Juveniles might be carried out of the Arctic in low concentration in the Arctic Water. If adults in the Atlantic live only below 2,000 m, there would be no possibility for them to enter the Arctic.

The most abundant of the seven Arctic species were *Spinocalanus longicornis* and *S. antarcticus.* The other species were in about equal, low concentration. None of these species have definitely been reported at the Arctic surface, but most have been taken, though rarely, as shallow as 25 or 50 m. The depth of highest concentration of each species varies: *S. longicornis* (100-400 m), *S. antarcticus* (180-400 m), *M. sulcifrons* (200-400 m), *M. crassus* (400-2,500 m), *S. horridus* (500-2,500 m), *S. elongatus* (900-2,500 m), and *S. polaris* (1,500-2,500 m). All have been collected at least as deep as 2,500 m.

The distribution of these species in seas adjacent to the Arctic is of great interest, although in most cases the distributions are not yet well defined. Surface layer copepods are transported from the Pacific into the Arctic (Johnson, 1963a, b) and perhaps intermittently in a southward surface flow, but there can be no exchange of strictly deepwater components because of the relatively shallow sill separating the two areas at Bering Strait.

Both *S. longicornis* and *S. antarcticus* have vertical distributions in the Arctic which include relatively high numbers in Arctic and Atlantic Waters, and therefore there appear to be no physical barriers to their movement in and out of the Arctic. However, only *S. longicornis* is reported in the North Atlantic and North Pacific; *S. antarcticus* may yet be found there since it is known from the Antarctic.

Spinocalanus horridus has been found only rarely in Arctic Water, and its movement out of the Arctic is probably restricted. It is found in the North Atlantic and undoubtedly enters the Arctic freely in the Atlantic Water.

Spinocalanus elongatus has a vertical distribution similar to *S. horridus*; its movement out of the Arctic is probably restricted. It has not been reported from the North Atlantic and may be the only species of Spinocalanidae endemic to the Arctic.

Spinocalanus polaris and *Mimocalanus sulcifrons*

enter the Arctic Waters in low numbers, and their movement out of the Arctic would be restricted. They have been found in the North Atlantic, but at too great depths to be transported into the Arctic.

Mimocalanus crassus was not found in the Arctic Water, and therefore probably does not leave the Arctic. It has been found in the Atlantic (Caribbean), as well as Indian Ocean, at depths sufficient to be carried into the Arctic if it occurs in the North Atlantic at similar depths.

Therefore, the Arctic Spinocalanidae could be characterized as follows: (1) *Spinocalanus longicornis* (Arctic, North Pacific, and North Atlantic, including Caribbean and Mediterranean); (2) *S. antarcticus* (bipolar; possibly a continuous distribution); (3) *S. horridus* (cosmopolitan); (4) *S. elongatus* (Arctic); (5) *S. polaris* (Arctic, with some transport to the deep Atlantic); (6) *Mimocalanus crassus* (probably cosmopolitan); and (7) *M. sulcifrons* (Arctic, with some transport to the deep Atlantic).

In view of the great vertical ranges, and evident tolerances of these Arctic species, it is interesting to speculate on the limited distributions of some of them. If there are no physical boundaries, perhaps there are boundaries imposed by the interactions of closely related species.

To examine this possibility one must consider which closely related species are present in the North Pacific and North Atlantic. Of the spinocalanids not found in the central Arctic, all North Pacific and North Atlantic *Spinocalanus* species except *S. abyssalis, S. magnus,* and *S. brevicaudatus,* all *Mimocalanus* species except *M. cultrifer,* all *Monacilla* species, and *Teneriforma naso* are reported at too great depths to be transported into the Arctic.

Five Arctic spinocalanids have limited distributions. *Spinocalanus polaris* has a rather unique morphology (see systematic review) and may not have an obvious counterpart in the North Atlantic. It may be more widely distributed than known at present, or it may, since it is deep living, be limited by interactions with other deep-living North Atlantic spinocalanids.

The three other Arctic *Spinocalanus* species of limited distribution, *S. longicornis, S. antarcticus,* and *S. elongatus,* would encounter three very closely related species in the North Pacific and North Atlantic, *S. abyssalis, S. magnus,* and *S. brevicaudatus* respectively. *Spinocalanus longicornis* and *S. abyssalis* have overlapping distributions in the North Atlantic (including the Caribbean and Mediterranean), but the other species apparently do not.

The last Arctic species of limited distribution, *Mimocalanus sulcifrons,* may, like *S. polaris,* be restricted by interactions with other deep-living North Atlantic spinocalanids, especially *M. cultrifer* and *M. nudus.*

FAMILY SPINOCALANIDAE VERVOORT, 1951

Description

P1 B1 without inner edge seta. B2 with minute seta near outer distal edge; long anterior seta near Ri base. *Re 3-segmented*; Re1 with or without outer distal spine, without inner seta; Re2 with 1 outer distal spine and 1 inner seta; *Re3 with 1 outer distal spine, 4 inner setae, and 1 bladelike terminal seta.* Terminal seta outer edge lightly serrate, inner edge plumose. *Ri 1-segmented,* with outer lobelike process near end, 2 terminal setae, and 1-3 inner setae; lobelike process more or less rounded, usually tipped with open, porelike points.

P2 B1 with inner seta (except *Mimocalanus crassus*). Surfaces (except *Spinocalanus polaris*) and margins of B2 nude. P3 B1 with inner seta (except *M. crassus*). B2 with surfaces and margins nude. P4 B1 with inner seta in females (except *M. crassus*), with or without inner seta in males. B2 margins nude.

P2 Ri 2-segmented; Ri1 without surface armament, with 1 inner seta; *Ri2 with 2 inner, 2 terminal, and 0-1 outer setae.*

P3-P4 Ri 3-segmented; Ri1 without surface armament, with 1 inner seta; Ri2 outer distal corner spiniform, *1 inner edge seta*; *Ri3 with 2 inner, 2 terminal, and 0-2 outer setae.* Number of setae on rami is identical in P3 and P4 in any one species.

P2-P4 Re 3-segmented; Re1 without posterior surface armament, with 1 outer spine and 1 inner seta; Re2 with 1 outer spine and 1 inner seta; *Re3 without serrate margins, with 3 outer edge spines, 5 inner edge setae, and 1 serrate bladelike terminal seta.*

Inner caudal seta small, directed ventrally; terminal 4 setae well developed but very fragile; outer seta small, minute, or, usually, apparently absent.

Female.—Length usually 0.8-3.58 mm, two species 4.20-4.7 mm. Prosome in dorsal view slender to robust ovoid, widest at Th1; *Ce and Th1 separate*; Th1-Th4 sometimes with lateral spinules in *Spinocalanus*; *Th4-Th5 usually separate, probably never completely fused*; Th5 lateral corners sometimes prolonged, never pointed; rostrum 2 symmetrical or asymmetrical long strong points, or single long blunt cone, or absent; *P5 absent* (see *Monacilla typica*). Urosome 4-segmented; genital segment longest, protruding ventrally one-fourth to one-half depth of rest of urosome; anal segment length ⅔-1 times caudal ramus; caudal ramus length 1-2½ times width (one ramus sometimes longer and wider).

A1 extending to anal segment or beyond caudal rami by up to 4 segments (except *S. angusticeps* and *S. validus,* and *Mimocalanus ovalis*); segments 8 and 9 usually fused, never completely separate; segment 10 not fused with 9 (partly fused in *M. heronae*); *segments 24 and 25, terminal segments, separate.*

A2 B1 with proximal hairs or setules and 1 long

plumose distal seta; B2 with 2 subequal setae; *Re of equal or greater length than Ri.* Re 7-segmented; Re1 with 0-2 setae; Re2 and Re3 separate, partly fused, or completely fused; Re2 with 0 or 2 setae; Re3-6 each with 1 seta; Re7 with 1 seta at about midlength and 3 terminal setae. Ri 2-segmented; Ri1 twice length of Ri2 (appearing much longer in *M. major*); Ri1 with 2 unequal setae; Ri2 with 2 lobes, inner lobe with 9 setae, outer with 7 setae and cluster of hairs along outer edge.

Mn B2 length about 1⅓ times width (appearing longer in *M. major*); Re 5-segmented; Re1-4 each with 1 long seta; Re5 with 2 terminal setae. Ri 2-segmented; Ri1 without saclike appendage on inner edge, with 4 inner edge setae (*S. antarcticus* and *S. magnus* with 2, and perhaps *Teneriforma naso* with 3); Ri2 with 11 setae (*S. antarcticus* apparently with 10).

Mx1 B2 about size of gnathobase, with 5 inner setae (*M. crassus* with 7). Gnathobase with 9 strong, thick, short, spinulose marginal setae, 0, 3, or 4 proximal posterior surface setae, 1 midmarginal anterior surface seta, and with or without 1 small distal anterior surface seta; distal posterior surface with spinules and denticles. Inner lobe-1 (beyond gnathobase) and inner lobe-2 about equal size; lobe-1 with 4, 5, or 6 setae depending on genus; lobe-2 with 4 setae, margins with spinules or stiff hairs. Ri terminal segment usually clearly separate, with 7 setae (9 in *M. crassus*). Proximal part of Ri indistinctly segmented (probably 2 segments); setation varying with genus. Mx1 outer lobe-1 usually prominent, rhomboidal; with 9 setae. Outer lobe-2 usually absent; on a few species small, nude or with minute seta. Re well-developed ovoid flap, smaller than B2, with 11 long setae; hairs on inner margin.

Mx2 length 1½-2 times width. Lobe-1 (proximal) with terminal midmarginal hook (see Fig. 116) and 6 setae (proximal 2 setae usually small); lobes-2-4 each with 3 setae; lobe-5 with 4 setae (proximal seta sometimes much reduced); lobe-6 small or reduced, with 2 setae (1 seta small or much reduced). Ri 3-segmented; Ri1-2 each with 1 long seta and usually 1 reduced posterior seta; Ri3 with 3 long setae. At least 1 seta on each of lobes-2-5, especially 4-5, thickened, shortened, and spinulose. Mx2 outer seta present or, apparently, absent.

Mxp B2 equal to or somewhat longer than B1; B1 and B2 together exceeding length of distal part. B2 with 5 setae and longitudinal row of stiff hairs, spinules, or denticles (see *Teneriforma naso*). Ri 5-segmented; length of Ri2 exceeding Ri1; Ri1-2 each with 4 setae (see *T. naso*); Ri3 with 3 setae (*S. elongatus* with 2; see also *T. naso*); Ri4 with 3 inner and 1 outer setae; Ri5 with 2 inner, 1 outer, and 1 terminal setae.

Male.—Length usually 0.78-2.9 mm, one species 4.4-5.08 mm. Prosome form varying with genus and usually differing from females, widest at Ce and/or Th1; Ce and Th1 separate or partly fused; Th1-Th4 without lateral spinules; Th4 and Th5 separate; Th5 at least slightly prolonged, never pointed; rostrum reduced knob, or long cone, or absent; *P5 simple*; *B2's uneven,* usually longer on left ("left-handed"), although 2 *Spinocalanus* spp. "right-handed"; uniramus or biramus. Urosome 5-segmented, segment 2 longest, segment 5 (anal segment) shortest (reduced, or length ⅔-1 times caudal ramus); caudal ramus length 1-2 times width.

A1 extending from distal Th4 to beyond caudal rami by up to 3 segments; segments 8 and 9 fused; segment 10 separate from or fused partly or completely with segment 9; *segment 20 merging with segment 21,* with noticeably wrinkled margins, *on right A1 in left-handed species and on left A1 in right-handed species*; *segments 24 and 25, terminal segments, separate*; segment 25 reduced or not; except in *Teneriforma naso,* all segments beyond 10 to near end more or less fused.

A2 segmentation and setation probably as in corresponding female, although several setae reduced. Proximal hairs or setules on B1, and hairs on Ri2, longer than on female. Re length about 2 times Ri because of short Ri1.

Mn B2 swollen, length about equaling width; *reduced blade* and reduced number and size of B2 setae; rami as female except Ri surface setules sometimes longer, and Ri1 setae sometimes reduced in size and number.

Mx1 gnathobase and other inner processes much reduced and fragile; outer processes similar to female.

Mx2 lobe-sizes reduced, wider apart than in female (especially in *Mimocalanus* spp.); setae reduced and fragile.

Mxp segmentation (see *Monacilla typica*) and inner setae usually as in female (*Spinocalanus elongatus* male with typical number of setae, and *S. polaris* male apparently with reduced number of setae). B1-2 narrow, without transverse spine-combs; Ri4-5 outer setae usually reduced or absent.

Swimming legs generally similar to those in corresponding female, although surface armature (spines, spinules, setules, hairs, etc.) sometimes varying slightly; number of setae on rami identical to corresponding female.

Remarks

Vervoort (1951) and Farran and Vervoort (1951a) separate the Spinocalanidae from the Pseudocalanidae in which the spinocalanids had been placed by previous workers; these are the first designations of the family and include the genera *Spinocalanus, Monacilla,* and *Mimocalanus,* to which Grice and Hulsemann (1965) added *Teneriforma* (as *Tanyrhinus* Farran). The publication by Vervoort (1951) was "published in the first half of 1951," while the publication by Farran and Vervoort (1951a) was "published in the second half of 1951, possibly in October" (W. Vervoort, pers. commun.).

KEY TO THE GENERA OF SPINOCALANIDAE

1. P1 Re1 without outer distal spine; P2-P4 posterior surface of Ri2 without row of spines . . . . . (3)
   P1 Re1 with outer distal spine (reduced in male *Monacilla typica*); P2-P4 posterior surface of Ri2 with 2 rows of spines (1 row reduced to small spinules on a few species) . . . . (2)
2. Rostrum absent; male anal segment usually reduced . . . . . *Spinocalanus*
   Rostrum 2 strong points in female, reduced to knob in male; male anal segment half length of caudal ramus . . . . . *Monacilla*
3. Rostrum absent. Female prosome length at least 4 times urosome. Caudal ramus length not more than 1½ times width. Male P5 uniramus, Re present on both legs . . . . . *Mimocalanus*
   Rostrum 1 long cone. Female prosome length about 3 times urosome. Caudal ramus length about 2 times width. Male P5 uniramus, Re present on left leg only . . *Teneriforma naso*

GENUS *SPINOCALANUS* GIESBRECHT, 1888

TYPE SPECIES: *Spinocalanus abyssalis* Giesbrecht, 1888.

Description

Rostrum absent. P1 Re1 with outer distal spine; Re1-2 together longer than Re3; *Ri with 1-3 inner setae. P2 Ri2 with 0-1 outer seta. P3-P4 Ri3 with 2 outer setae* (*S. polaris* with 1 outer seta). *Posterior surface of certain segments of swimming legs with rows of spines* (see below). Caudal rami and caudal setae sometimes asymmetrical.

Female.—Prosome in dorsal view slender to robust ovoid, Th5 lateral corners sometimes prolonged; Th1-Th4 sometimes with lateral spinules, sometimes varying in number left to right. Prosome length 2¾-3⅔ times urosome (*S. angusticeps, S. antarcticus,* and *S. validus* about 4¼). Caudal ramus length 1-2 times width.

A1 segment 2 length about 1½ times segment 1; segments 8 and 9 fused. A1 usually exceeding caudal rami by 1-4 segments (see *S. angusticeps, S. magnus,* and *S. validus*). Armature given in Table 4.

A2 Re length exceeds Ri by 20%. *Re1 with 0-2 setae*; *Re2 and Re3 fused*; *Re2 with 2 setae.*

Mn B2 with 4 inner setae, usually also with distal row of long setules on anterior surface (and then also with row of long setules on Ri1 surface).

Mx1 gnathobase posterior surface with proximal clusters of spinules and denticles; proximal posterior surface with 3 or 4 setae; distal anterior seta present or absent. Inner lobe-1 with 6 setae. Proximal part of Ri with 4 proximal and 5 distal setae. Outer lobe-2 absent.

Mx2 length 1½-1¾ times width; small to strong proximal outer hump, usually armed with hairs, setules, and/or spinules. Lobe-5 with 4 strong setae; posterior surface of base may have spines. Lobe-6 small, with 2 setae (1 seta small). Ri segments not reduced. Mx2 outer seta present or, apparently, absent.

Mxp B1 sometimes with transverse spine-comb midlength on outer anterior and posterior edge. B2 sometimes also with transverse spine-comb about one-third length on outer anterior and posterior edge. B1 with 3 groups of 3 setae each. B2 with longitudinal row of stiff hairs or stiff setules; 2 setae about midlength, 1 seta more distal, and 2 distal setae. Form of Ri4-5 outer setae varying with species.

P1 Re3 sometimes with posterior surface spines.

P2-P4 Re2 distal anterior surface with 1 row of spinules.

P2 Re2 posterior surface with 1 row of spines (perhaps 2 rows in *S. hirtus*; no spines in *S. angusticeps* or *S. validus*). P3-P4 Re2 posterior surface with 1-2 rows of spines.

P2-P3 Re3 posterior surface with 1-3 rows of spines (none on P2 posterior surface in *S. angusticeps* or *S. validus*). P4 Re3 with or without posterior surface spines or spinules.

P2-P4 Re terminal seta with moderately coarse serrate outer edge (20-50 primary teeth); outer flange narrow.

P2-P4 Ri2 posterior surface with 2 rows of spines; 1 row sometimes reduced to small spinules on a few species.

P3 Ri3 posterior surface usually with 2 rows of spines, but at least 1 row of spines or denticles. P4 Ri3 posterior surface with 2 rows of spines.

P4 B1 with transverse row of setules (spinules on *S. polaris*) on posterior surface near inner seta.

Male.—Prosome in dorsal view usually not ovoid; anterior irregular or rounded, with central knoblike protrusion; posterior usually somewhat rectangular. Ce expanded dorsolaterally, nearly covering Th1 (only slightly in *S. magnus* and not at all in *S. angusticeps* and *S. antarcticus*). Ce and Th1 separate or partly fused. Prosome length 1⅔-2⅔ times urosome. *Anal segment usually reduced* (except one-half to two-thirds length of caudal ramus in *S. angusticeps, S. antarcticus, S. magnus,* and *S. validus*). Caudal ramus length 1-1¾ times width.

A1 segment 2 somewhat longer than segment 1; segment 10 partly fused with segment 9; segment 25 reduced (except in *S. angusticeps, S. antarcticus, S. magnus,* and perhaps *S. validus*). Armature given in Table 4.

Swimming legs generally similar to those in corresponding female, although surface armament sometimes variable; rows of spines on posterior sur-

face of some segments in female sometimes circular clusters in male. P4 B1 without inner transverse row of setules or spinules on posterior surface; with or without inner seta.

P5 biramus or very asymmetrical uniramus, usually left-handed (*S. polaris* and *S. similis* right-handed); each Re essentially 3-segmented, usually right Re1 and Re2 more or less fused on left-handed species.

KEY TO THE SPECIES OF *SPINOCALANUS*

GROUP A. P1 Ri with 2 inner setae; P2 Ri2 with 0-1 outer seta; P3-P4 Ri3 with 2 outer setae. A2 Re1 with 1-2 setae. *Female*: Th5 lateral corners prolonged or not; Th1-Th4 with or without lateral spinules. Mxp B1 with 0, 1, or 3 transverse spine-combs; B2 generally with transverse spine-comb, 2 species variable, 1 species without; Ri4-5 outer 2 setae fragile, bladelike, nude, tapered toward each end; Ri5 inner edge with spinules. *Male*: Anal segment reduced. A1 segment 25 reduced. Mxp Ri4-5 outer 2 setae reduced, may be bladelike as in female; inner setae of Ri2-5 not inflated; Ri5 inner edge with or without spinules. P5 biramus, left- or right-handed (14 species) . . . . . (1)

GROUP B. P1 Ri with 3 inner setae; P2 Ri2 with 1 outer seta; P3-P4 Ri3 with 2 outer setae. A2 Re1 without setae. *Female*: Th5 lateral corners prolonged; Th1-Th4 without lateral spinules. Mxp B1-2 without transverse spine-combs; Ri4-5 outer 2 setae may be asymmetrically plumose and as large and strong as other large terminal setae, or lightly plumose, moderately fragile, thin, and relatively short; Ri5 inner edge without spinules. *Male*: Anal segment not reduced. A1 segment 25 not reduced. Mxp Ri4-5 outer 2 setae reduced; inner setae of Ri2-5 not inflated; Ri5 inner edge without spinules. P5 left-handed; uniramus and very asymmetrical, or biramus (4 species) . . . . . (17)

GROUP C. P1 Ri with 1 inner seta; P2 Ri2 with no outer seta; P3-P4 Ri3 with 1 outer seta. A2 Re1 with 1 seta. *Female*: Th5 lateral corners prolonged; Th1-Th4 without lateral spinules. Mxp B1-2 without transverse spine-combs; Ri4-5 outer 2 setae lightly plumose, moderately fragile, thin, and relatively short; Ri5 inner edge without spinules. *Male*: Anal segment reduced. A1 segment 25 reduced. Mxp Ri4-5 outer 2 setae reduced or absent; inner setae of Ri2-5 inflated; Ri5 inner edge without spinules. P5 biramus, right-handed (1 species) . . . . . 26. *S. polaris*

1. P2 Ri2 with 1 outer seta. A2 Re1 with 2 setae. Female Th1-Th4 with or without lateral spinules (10 species) . . . . . (5)
   P2 Ri2 with no outer seta. A2 Re1 with 1 seta. Th1-Th4 without lateral spinules (4 species) . . . . . (2)
2. P3-P4 Re2 proximal posterior surface spines broad, leaflike. *Female*: Th5 rounded, not prolonged. Mxp B1 without transverse spine-comb. *Male*: P5 longest Ri about equal to or less than 1½ times length of other Ri . . . . . (4)
   P3-P4 Re2 proximal posterior surface spines relatively narrow, not leaflike. *Female*: Th5 slightly prolonged. Mxp B1 with 1 or 3 transverse spine-combs. *Male*: P5 longest Ri more than 1½ times length of other Ri . . . . . (3)
3. *Female*: A1 terminal 2 segments elongate. Mxp B1 with 3 transverse spine-combs; Ri3 with 2 setae. *Male*: Left-handed . . . . . 25. *S. elongatus*
   Female: A1 terminal 2 segments of moderate length and width. Mxp B1 with 1 transverse spine-comb; Ri3 with 3 setae. *Male*: Right-handed . . . . . 21. *S. similis*
4. *Female*: Prosome, slender ovoid, length greater than 2.4 times width. *Male*: P5 Ri lengths very unequal . . . . 1. *S. abyssalis*
   Female: Prosome, somewhat robust ovoid, length less than 2.4 times width. *Male*: P5 Ri lengths about equal . . . . 2. *S. longicornis*
5. Female . . . . . (8)
   Male (unknown for 7 of 10 species) . . . . (6)
6. P5 Ri not reaching base of Re3 terminal setae . . . . . 10. *S. horridus*
   P5 Ri reaching beyond base of Re3 terminal setae . . . . . (7)
7. P1 Re3 posterior surface without spines . . . . . 27. *S. brevicaudatus*
   P1 Re3 posterior surface with spines . . . . . 43. *S. terranovae,* new species
8. Th5 lateral corners rounded . . . . . (10)
   Th5 lateral corners more or less prolonged, not rounded . . . . . (9)
9. Length less than 2 mm. Mxp B2 without transverse spine-comb. P1-P4 B1 surfaces without dense covering of fine hairs. (Male unknown.) . . . . . 31. *S. abruptus*
   Length greater than 2 mm. Mxp B2 with transverse spine-comb(?). P1-P4 B1 surfaces with dense covering of fine hairs. (Male unknown.) . . . . . 8. *S. hirtus*
10. At least 1 segment Th1-Th4, right and/or left, with ventrolateral spinules . . . . . (13)
    Th1-Th4 without spinules . . . . . (11)
11. Mxp B1 with transverse spine-comb. (Male unknown.) . . . . . 39. *S. aspinosus*
    Mxp B1 without transverse spine-comb . (12)
12. P1 Re3 posterior surface without spines. P2 B1 surface without spines (spinules and/or setules only). P3 Re2 posterior surface with row of spines distal from row of strong

spines. P4 B2 surface nude or with thin setules . . . . . 27. *S. brevicaudatus*

P1 Re3 posterior surface with spines. P2 B1 surface with strong spines. P3 Re2 posterior surface with row of denticles distal from row of strong spines. P4 B2 surface with spinules . . . . . 43. *S. terranovae,* new species

13. Mxp B1 without transverse spine-comb. (Male unknown.) . . . . . 9. *S. spinosus*

Mxp B1 with transverse spine-comb . . . (14)

14. Mx2 posterior surface of lobe-5 base with spines. (Male unknown.) . . 37. *S. usitatus*

Mx2 posterior surface of lobe-5 base without spines . . . . . (15)

15. Mxp B1 transverse spine-comb on conspicuous protuberance. (Male unknown.) . . . . . 38. *S. hoplites*

Mxp B1 transverse spine-comb not on conspicuous protuberance . . . . . (16)

16. Length greater than 1.7 mm. Prosome elongate ovoid . . . . . 10. *S. horridus*

Length less than 1.7 mm. Prosome robust ovoid. (Male unknown.) . . . . . 40. *S. oligospinosus*

17. *Female*: A1 reaching at least to anal segment. Mxp Ri4-5 outer 2 setae asymmetrically plumose and as large and strong as other large terminal setae. P2 Re2-3 posterior surface with 1 row of spines. P4 Re3 posterior surface nude. *Male*: P4 B1 with inner seta . . . . . (19)

Female: A1 not reaching beyond genital segment. Mxp Ri4-5 outer 2 setae lightly plumose, moderately fragile, thin, and relatively short. P2 Re2-3 posterior surface nude. P4 Re3 posterior surface with many small spinules. *Male*: P4 B1 without inner seta . . . . . (18)

18. Length greater than 3.3 mm. *Female*: Prosome slightly robust ovoid. P2 Re1 outer spine typical. *Male*: Ce expanded dorsolaterally, nearly covering Th1. P5 biramus . . . . . 12. *S. validus*

Length less than 3.3 mm. *Female*: Prosome long slender ovoid. P2 Re1 outer spine forming strongly bent hook. *Male*: Ce not expanded. P5 essentially uniramus (rudimentary left Ri), very asymmetrical . . . . . 13. *S. angusticeps*

19. *Female*: Prosome in dorsal view slender long ovoid; in lateral view with gentle, uneven forward slope. Prosome length 3¼ times urosome. *Male*: Ce slightly expanded dorsolaterally. P5 biramus . . 4. *S. magnus*

Female: prosome in dorsal view robust ovoid; in lateral view with abrupt, even forward slope. Prosome length 4¼ times urosome. *Male*: Ce not expanded. P5 uniramus, very asymmetrical . . . . . 5. *S. antarcticus*

1. *Spinocalanus abyssalis* Giesbrecht, 1888

(Figures 4-10, 148)

Spinocalanus abyssalis Giesbrecht, 1888, p. 335. —Giesbrecht, 1892, p. 209-213, pl. 13, fig. 42-48; pl. 36, fig. 49. —Giesbrecht and Schmeil, 1898, p. 31. —?Thompson, 1903, p. 16, pl. 1, fig. 6. —van Breemen, 1908 (part), p. 28-29, fig. 27d (only). —Brodsky, 1950, p. 129-130, fig. 49. —Park, 1970, p. 481-482, fig. 13-22. —Grice, 1971, p. 278-280, fig. 3I-J.

Spinocalanus abyssalis var. *pygmaeus*. —Farran and Vervoort, 1951a (part), p. 2-3, fig. 1f, h(only). Not *S. abyssalis* var. *pygmaeus* Farran, 1926.

Spinocalanus parabyssalis Park, 1970 (part), p. 483-485, fig. 34-36; male only.

TYPE SPECIMEN: Neotype, female (1.20 mm) USNM 142700.

TYPE LOCALITY: Central Pacific, 1,000-4,000 m.

MATERIAL STUDIED: 1 female (1.0 mm), sample 8 (Table 3); 1 female (1.13 mm), sample 11; 3 females (1.23, 1.25, 1.27 mm), sample 22; 1 female (0.875 mm), sample 24; 2 females (0.98, 1.025 mm), sample 25; 1 female (0.90 mm), sample 28; 1 female (1.025 mm), sample 29; 3 females (1.10, 1.23, 1.30 mm) and neotype female (1.20 mm), sample 30; 2 females (1.08, 1.22 mm), sample 31; 1 female (1.30 mm) and 1 male (1.13 mm), sample 55.

Description

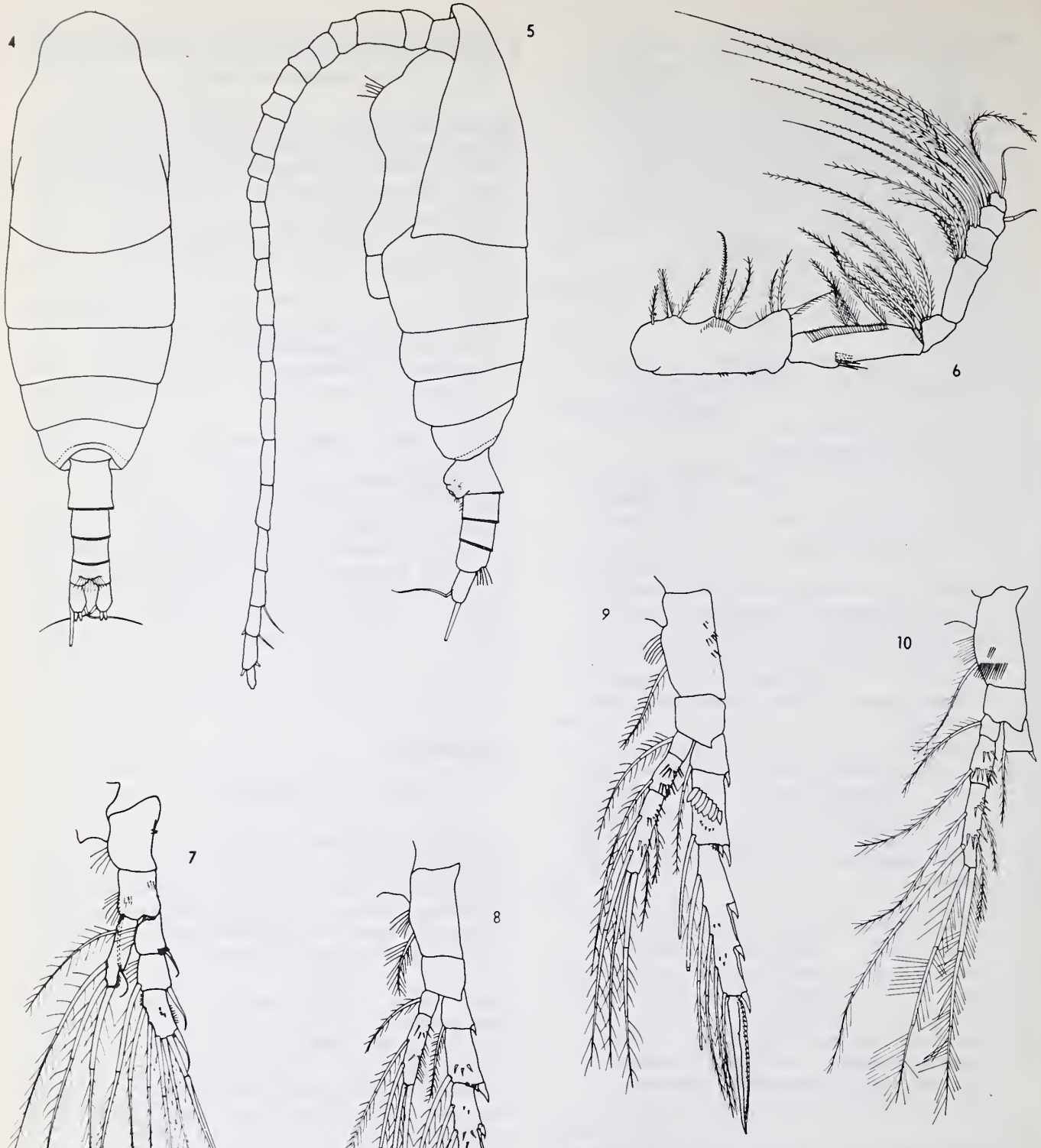
P1 Ri with 2 inner setae; P2 Ri2 with no outer seta.

Female.—Length (0.8?-) 0.85-1.32 mm (Figs. 4, 5). Prosome in dorsal view slender ovoid; prosome length greater than 2.4 times width. Head rounded in dorsal view, in lateral view with flat, gentle forward slope. Th4 and Th5 may be separate or partly fused, especially dorsolaterally; Th5 lateral corners rounded, not prolonged; Th1-Th4 without lateral spinules. Prosome length slightly more than 3 times urosome. Genital segment slightly longer than wide, protruding ventrally one-half depth of rest of urosome; caudal rami length nearly 2 times width, symmetrical. Caudal setae incomplete on all specimens examined, bases symmetrical. Supra-anal plate with fringe of long hairs.

A1 exceeding caudal rami by about 4 segments; terminal segments (Fig. 148) of moderate length and width. Apparent deviation: I-2s; remainder as Table 4.

A2 Re1 with 1 seta [Giesbrecht (1892) reported 2 setae].

Mn with row of setules on distal anterior surface of B2 and on surface of Ri1. Blade with 4 strong, evenly spaced ventral teeth, 4 smaller closer spaced dorsal teeth, and dorsal seta.



Spinocalanus abyssalis, female

Figure 4.—Habitus, dorsal view; sample 30 (Table 3); scale B.
Figure 5.—Habitus, lateral view; sample 30; scale B.
Figure 6.—Mxp; sample 30; scale D.
Figure 7.—P1; sample 30; scale D.
Figure 8.—P2; sample 30; scale D.
Figure 9.—P3; sample 30; scale D.
Figure 10.—P4; sample 30; scale D.

Mx1 gnathobase with 3 proximal setae [Park (1970, fig. 17) shows 4] on posterior surface; without seta on distal anterior surface.

Mx2 with moderately strong, setule-covered hump on proximal outer edge; outer seta present; posterior surface of lobe-5 base with spines.

Mxp (Fig. 6) B1 without spine-comb; longitudinal row of stiff hairs on midanterior surface; outer edge with 2-3 clusters of short setules. Transverse spine-comb of 6-7 moderate spines present or not on B2. B2 with longitudinal row of stiff hairs. Two outer setae on Ri4-5 nude, bladelike, tapering toward each end; spinules on inner edge of terminal Ri5.

P1 (Fig. 7) B1 surface with few setules; inner margin with hairs. B2 surface with few setules and hairs; inner margin with hairs. Re1 anterior surface with outer distal row of spinules; Re2 surface nude; Re3 posterior surface with 0-4 spines. Re1 outer spine reaching to or beyond base of Re2 outer spine; Re2 outer spine reaching beyond base of Re3 outer spine. Ri surface nude.

P2 (Fig. 8) B1 surface nude or with few setules, inner margin with hairs. P3 (Fig. 9) B1 surface with few setules, inner margin with hairs. P4 (Fig. 10) B1 surface with few thin setules in addition to posterior transverse row; inner margin with hairs; B2 nude.

Re2 posterior surface on P3 with proximal row of ca. 8 very broad, flat, leaflike spines and distal row of 5-6 denticles; on P4 with proximal row of ca. 9 similar leaflike spines and distal row of ca. 6 small spines.

Re3 posterior surface on P2 with 3 rows of 2-4 spines each; on P3 without proximal row of spines, but with 2 distal rows of a few small spines; on P4 with 3 rows of up to 5 small spines.

P3 Ri3 posterior surface with 2 rows of spines.

Re terminal seta with following number of primary teeth: P2 (24-38); P3 (27-34); P4 (25-29). P2 terminal seta slightly longer than Re3; P3 terminal seta somewhat shorter than Re3.

Male.—Length 0.90-1.2 mm. Prosome anterior irregular in dorsal view, posterior somewhat rounded; in lateral view with gentle forward slope. Ce and Th1 partly fused. Prosome length 2 times urosome. Caudal rami length slightly more than width, symmetrical. Caudal setae unknown.

A1 reaching about end of Th4.

P4 B1 proximal outer surface with setules; without inner seta.

P5 biramus, left-handed; left B1 reaching one-third length of right B2; left B2 reaching middle of right Re1. Left leg longest; left Re (including terminal blade) longest; right Ri longest. Order of length, longest to shortest, of Re segments: left 1, 2, 3; right 1 = 2, 3. Left Ri reaching middle of left Re2; right Ri reaching middle of longest terminal seta of right Re. Each Re with 1 small and 1 moderate bladelike terminal setae.

Remarks

Giesbrecht (1888, 1892) examined "about a half-dozen" mutilated females on which he based his description of the first *Spinocalanus* species, *S. abyssalis*. He did not illustrate the prosome; his figures of appendages, characteristically excellent, differentiated *S. abyssalis* from the other Pseudocalanidae with which it was placed. However, the lack of information on body form and probably also the lack of a figure of P2 (even though Giesbrecht stated that P2 Ri2 had only 4 setae) led subsequent investigators to unite more or less closely related species with *S. abyssalis*. It is a curious coincidence that Sars (1900) mistakenly illustrated P2 Ri2 of Arctic *S. longicornis* with 5 setae (rather than 4), and later (1903) mistakenly illustrated the same segment on Norwegian *S. brevicaudatus* with 4 setae (rather than 5). Sars also failed to illustrate the surface spines of the swimming legs of *S. brevicaudatus*, and when he claimed that these three species were identical, it became effectively impossible to reconcile the descriptions solely from the literature.

Farran (1926) proposed *Spinocalanus abyssalis* var. *pygmaeus* for the smaller of at least two forms, thereby making the larger form the "typical" species, even though Giesbrecht's specimens were small. This was repeated by most investigators and served to further confound the concept of "*Spinocalanus abyssalis*."

Specimens examined in this study agreed essentially with the description and figures of Giesbrecht (1892). Giesbrecht's unit in measuring A1 segments should have read 0.005 mm, not 0.05 mm. The Mxp he illustrated lacked the fragile outer seta on Ri4. Giesbrecht stated that P1 Re3 posterior surface may or may not have spines, though the illustrated P1 lacked these spines.

References to *S. abyssalis* by Giesbrecht and Schmeil (1898), van Breemen (1908, part), and Brodsky (1950) are solely repetitions of the work of Giesbrecht (1892).

Thompson (1903) illustrated P5 of a juvenile male from the west of Ireland; no size was reported. The figure does not agree with P5 of male stage V *S. longicornis* (see Fig. 34) or *S. brevicaudatus* (With, 1915, fig. 15e). Thompson's specimen could be *S. abyssalis*, although possibly it is not even a *Spinocalanus* species.

Park's (1970) description and figures of *S. abyssalis* agree with Pacific specimens and include the first habitus illustrations of this species.

Grice's (1971) figures also agree with the description of *S. abyssalis*. The references to these figures are correct in his key, but the figure legend transposed the caption for *S. abyssalis* and *S. parabyssalis* (G. Grice, pers. commun.).

Farran's (1926) first use of *S. abyssalis* var. *pygmaeus* referred at least to *S. longicornis*, but possibly also to *S. abyssalis* since both species occur in

the North Atlantic (see *S. longicornis*). The description of *S. abyssalis* var. *pygmaeus* by Farran and Vervoort (1951a, part) is from Giesbrecht (1892).

Park (1970) described a new species, *S. parabyssalis*, the female of which has been identified in the present review as *S. longicornis*. The male, however, does not agree with the male *S. longicornis*, but is consistent with what would be likely for the male of *S. abyssalis*. It is therefore believed that *S. parabyssalis* male is the male of *S. abyssalis*. Park reported one male *S. parabyssalis*; a male which he reported as *S. brevicaudatus* (1.38 mm) has been identified in the present study as a second male *S. abyssalis* (1.13 mm); both males were from the same sample, with numerous female *S. abyssalis* and *S. longicornis* (sample 55, Table 3).

Giesbrecht's type specimens appear to have been lost (Bruno Scotto di Carlo, pers. commun.). In view of the high number of common characteristics of *S. abyssalis* and *S. longicornis*, a neotype of *S. abyssalis* has been deposited in the U.S. National Museum (USNM 142700). The neotype (sample 30, Table 3) is from nearly the same area and depth as Giesbrecht's specimens; this female is consistent with what is known of the original type material and corresponds to the description given here.

Of the material examined in the present study, *S. abyssalis* females from samples 8 and 22 had separate Th4 and Th5 (4 specimens); those from samples 11, 24, 25, 28-31, and 55 had partly fused Th4 and Th5 (13 specimens). A Mxp B2 spine-comb was absent on 7 specimens from samples 30, 31, and 55; a B2 spine-comb was present on 9 specimens from samples 8, 11, 22, 24, 25, and 29.

Distribution

Many records of *Spinocalanus abyssalis* cannot be interpreted; unless at least the length of specimens was given, the record could reflect one or a mixture of several species. If lengths were given, a record might be presumed based on the known distribution of the species. Specimens reported from transitional areas should be reexamined. In reports of size groups and in specimens examined in this study, there is a clear discontinuity between females of the "*pygmaeus*" form (*S. abyssalis* and *S. longicornis*) and the "typical" form (*S. brevicaudatus* or other species), the former smaller, and the latter larger, than 1.40 mm (see *S. brevicaudatus* for several records of "*S. abyssalis*" not mentioned here).

Probable or confirmed occurrences of *S. abyssalis* (reported as *S. abyssalis* with length range given, and/or *S. abyssalis* var. *pygmaeus*) are listed below. Those with superscript probably or definitely include other species—see distribution of (a) *S. brevicaudatus*, (b) *S. horridus*, and (c) *S. terranovae:*

Pacific Ocean
- North: Minoda (1971)[b], 160-2,000 m.
- Northeast: Fleminger (1967), 0-140 m. —von Vaupel-Klein (1970)[a], 0-1,200 m.
- Central: Giesbrecht (1888, 1892), 1,000-4,000 m. —Present study, 0-1,000 m.
- Northwest: Tanaka (1953, 1956)[a], below 200 m. —Minoda (1971)[b], 457-500 m.
- Southwest: Farran (1936), ca. 300 m.
- Indo-Pacific: Vervoort(1946)[a], 340-2,500 m.

Indian Ocean
- Northwest: Sciacchitano (1930), 1,000 m.
- West: Grice and Hulsemann (1967), 750-4,000 m.

Atlantic Ocean
- Northeast: Present study.
- Eastern Mediterranean Sea: Grice (1971), 1,050-1,200 m.
- Southeast: Unteruberbacher (1964)[a], 0-100 m.
- Caribbean Sea: Park (1970), 203-2,800 m.

Antarctic
- Pacific Sector: Farran (1929)[c], 0-400 m. —Bradford (1971)[c], 0-1,300 m.
- Indian Sector: Vervoort (1957, 1965)[c], 250-1,000 m. —Tanaka (1960)[c], 0-400 m.
- Atlantic Sector: Hardy and Gunther (1935), 500-2,000 m.

Records of small species (usually reported as *S. abyssalis* var. *pygmaeus*) from the North Pacific, North Atlantic, or Mediterranean are complicated because of the co-occurrence of *S. abyssalis* and *S. longicornis*. Farran (1908), Grice (1963), Grice and Hulsemann (1965), Wheeler (1970), Vives (1970, 1971), and Roe (1972a, b) may have examined either or both species. Some specimens as short as 0.8-0.83 mm may be either or both species. Some of these records also include larger forms, probably *S. brevicaudatus*.

Some records of *S. abyssalis* contain no information which would help to determine the species: Wolfenden (1904, 1911), Farran (1905), Sars (1907), Lysholm and Nordgaard (1945), Furuhashi (1961, 1966), Shmeleva (1964), and Vinogradov (1970).

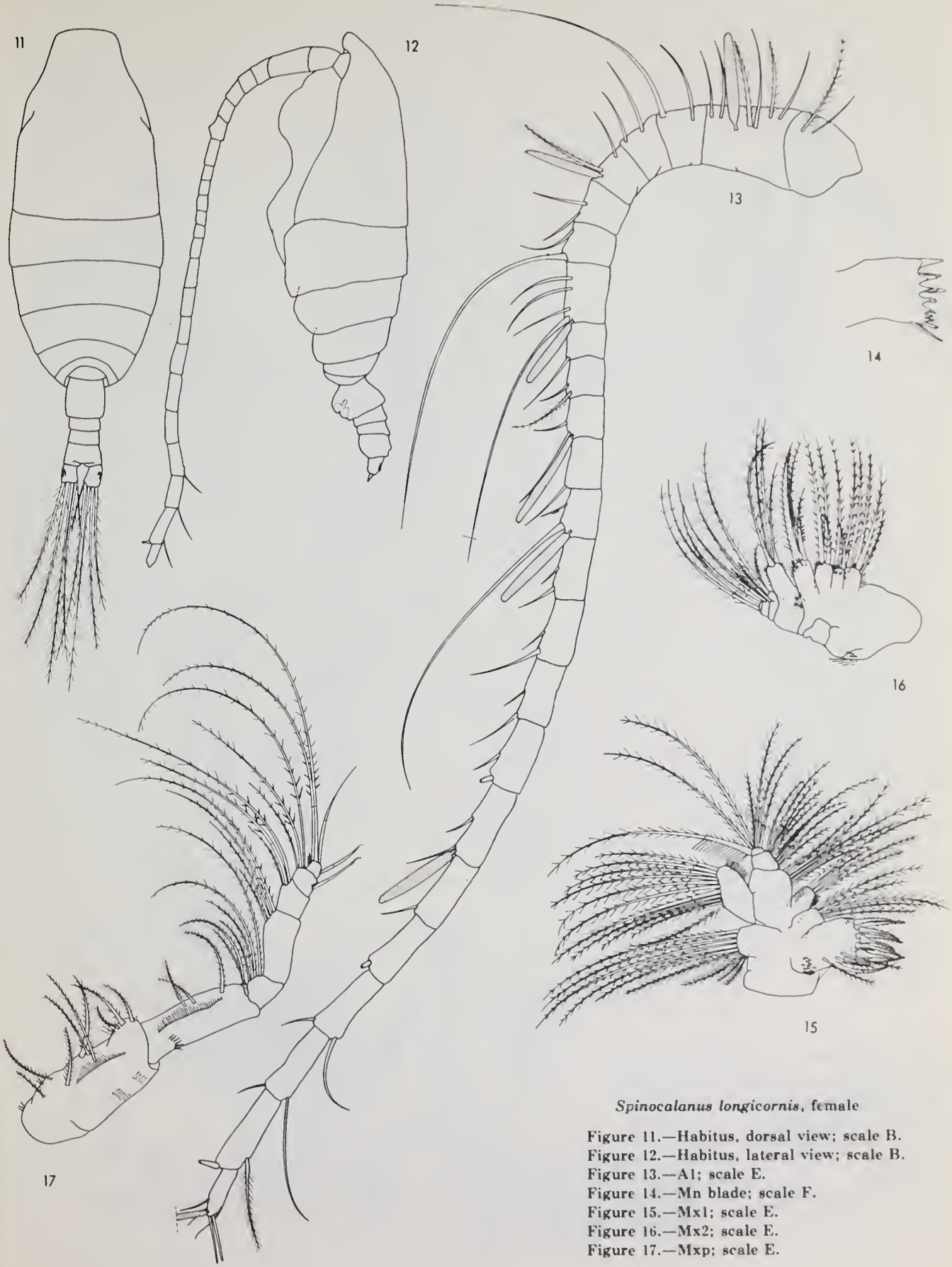
Wilson's (1942) record of *S. abyssalis* appears to be erroneous, inasmuch as the samples referred to, and labeled by Wilson, contained no Spinocalanidae. Wilson's (1950) samples from Hawaii and Peru also contained no Spinocalanidae; the other two samples, from Bering Sea and North Pacific, were not located.

2. *Spinocalanus longicornis* Sars, 1900

(Figures 11-34, 149)

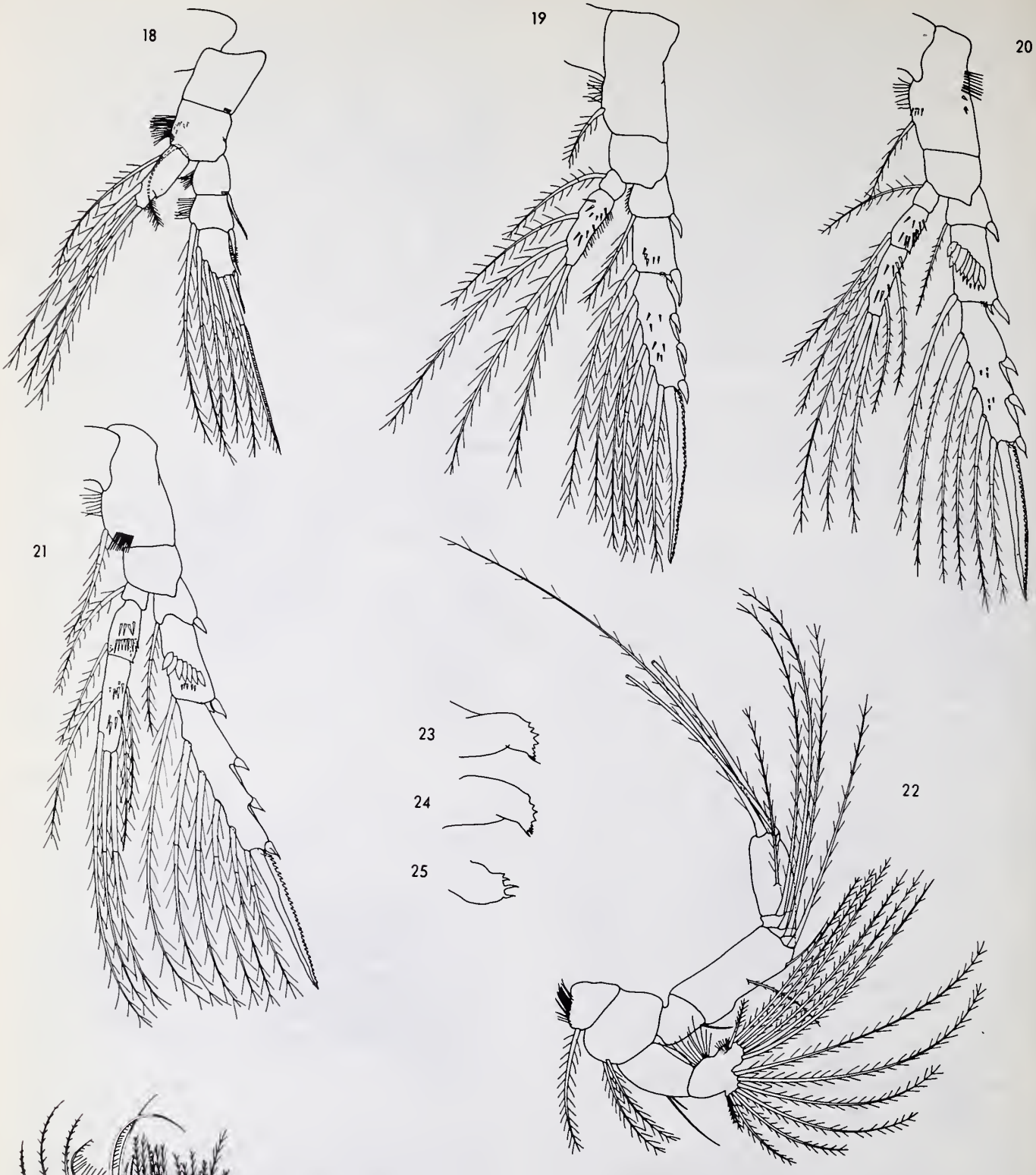
Spinocalanus longicornis Sars, 1900 (part), p. 75-78, pl. 22, fig. 1-12; female only. —Mrázek, 1902, p. 521. —Brodsky, 1950, p. 133-134, fig. 54. —Vidal, 1971, p. 19, 24, fig. 48-49, 52-55.

Spinocalanus schaudinni Mrázek, 1902, p. 509-512, 521, pl. 4, fig. 1-12; pl. 5, fig. 1. —van Breemen, 1908 (part), p. 29, fig. 28 (only).



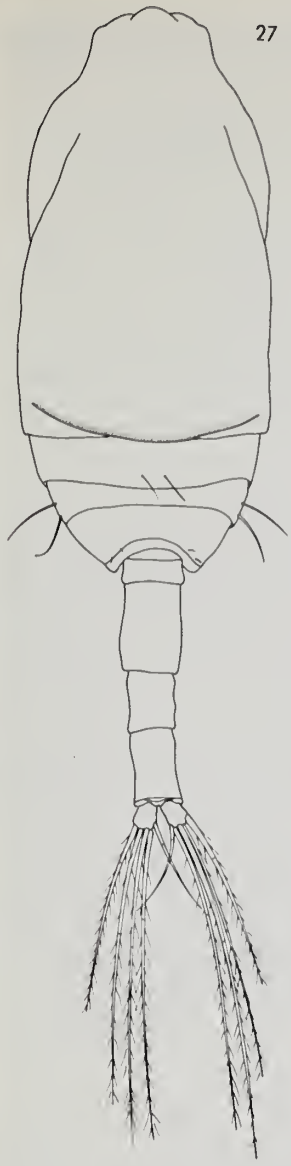
Spinocalanus longicornis, female

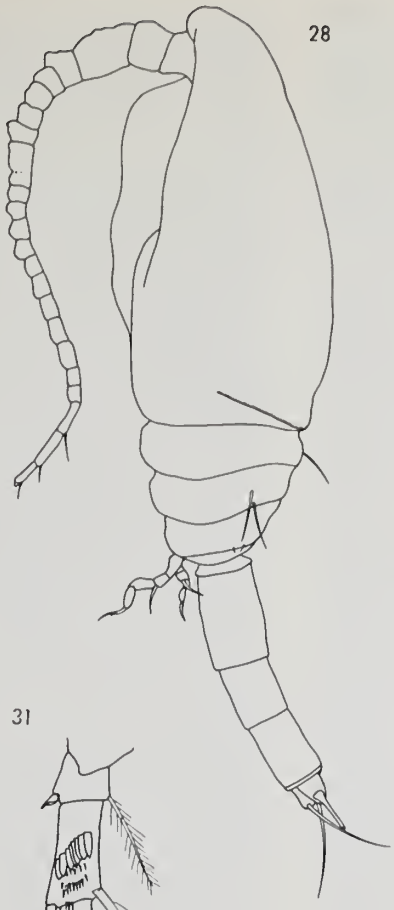
Figure 11.—Habitus, dorsal view; scale B.
Figure 12.—Habitus, lateral view; scale B.
Figure 13.—A1; scale E.
Figure 14.—Mn blade; scale F.
Figure 15.—Mx1; scale E.
Figure 16.—Mx2; scale E.
Figure 17.—Mxp; scale E.

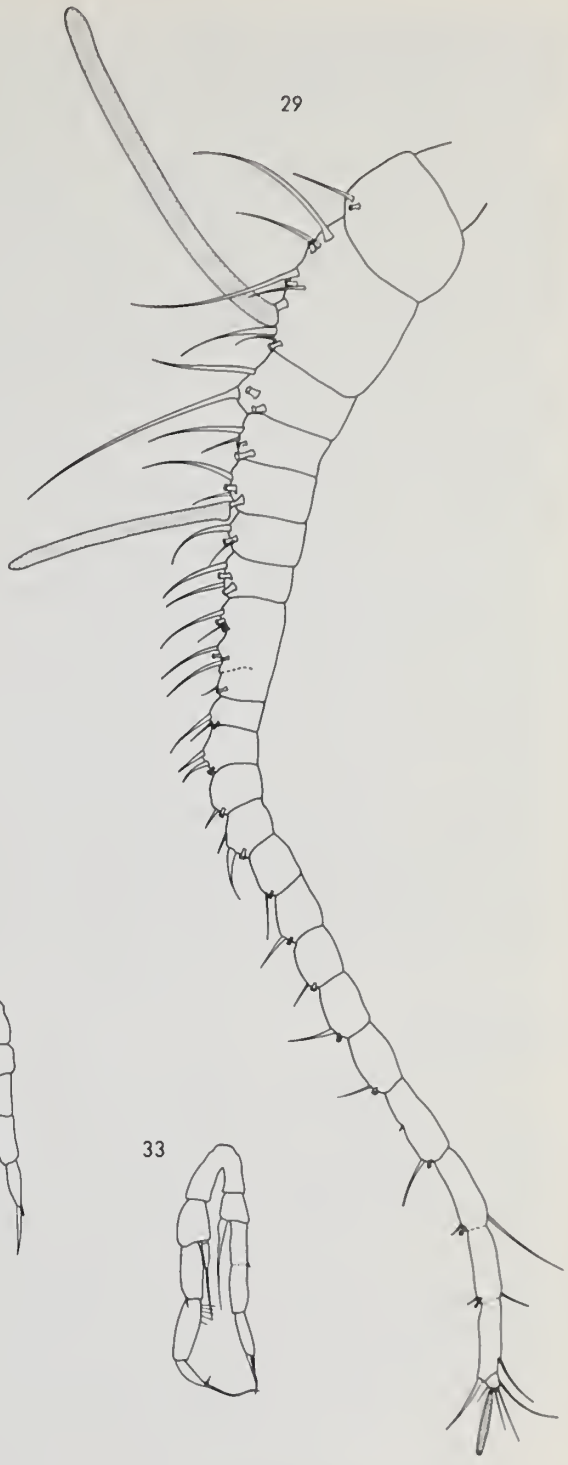


Spinocalanus longicornis

Figure 18.—Female, P1; scale E.
Figure 19.—Female, P2; scale E.
Figure 20.—Female, P3; scale E.
Figure 21.—Female, P4; scale E.
Figure 22.—Male, A2; scale E.
Figure 23.—Male, Mn blade; scale F.
Figure 24.—Male, Mn blade; scale F.
Figure 25.—Male, Mx1 gnathobase; scale F.
Figure 26.—Male, Mx2; scale E.







Spinocalanus longicornis, male

Figure 27.—Habitus, dorsal view, scale B.
Figure 28.—Habitus, lateral view; scale B.
Figure 29.—A1; scale E.
Figure 30.—Mxp; scale E.
Figure 31.—P4, left; scale D.
Figure 32.—P5; scale E.
Figure 33.—P5; sample 23 (Table 3); scale D.
Figure 34.—Stage V, P5; sample 15; scale D.

Spinocalanus abyssalis var. *pygmaeus* Farran, 1926, p. 243 (at least part).

Spinocalanus parabyssalis Park, 1970 (part), p. 483-485, fig. 23-33; female only. —Grice, 1971, p. 278-280, fig. 3E-F.

TYPE SPECIMEN: Holotype, female, on slide F6511, OSLO.

TYPE LOCALITY: Central Arctic Ocean, Eurasian Basin, ca. 100 m.

MATERIAL STUDIED: 2 females (0.95, 1.08 mm), sample 1 (Table 3); holotype female, 38 paratype females (0.92-1.05 mm, mean = 0.97 mm), 10 damaged females, 5 male stage V (0.88-0.95 mm, mean = 0.91 mm), and 2 damaged male stage V from sample 15; 6 females (0.95-1.10 mm, mean = 1.03 mm), 1 female stage V (0.88 mm), and 1 male (1.08 mm), sample 23; 1 female (0.95 mm), sample 46; 1 female (0.88 mm), "*Spinocalanus parabyssalis* Park, holotype, 0.98 mm," sample 55; 6 females (1.08-1.24 mm, mean = 1.18 mm), sample 60; 2 females (1.08, 1.1 mm), sample A1 (Table 1); 1 female (1.05 mm), sample A2; 1 female (1.15 mm), sample A4; 2 females (1.08, 1.30 mm) and 1 male (1.25 mm), sample A6; 1 male (1.28 mm), sample A21; 1 male (1.36 mm), sample A22; 4 males (1.24-1.40 mm, mean = 1.31 mm), sample A23; 1 male (1.24 mm), sample A27; 5 females (1.15-1.20 mm, mean = 1.17 mm), sample A33; 5 females (1.12-1.24 mm, mean = 1.17 mm) and 2 males (1.36, 1.40 mm), sample A34; 2 males (1.36, 1.40 mm), sample A35; 3 males (1.28, 1.36, 1.40 mm), sample A36; 6 females (1.08-1.21 mm, mean = 1.14 mm), sample A48; 1 female (1.15 mm), sample A50.

Description

P1 Ri with 2 inner setae; P2 Ri2 with no outer seta.

Female.—Length (0.8?-) 0.88-1.30 mm (Figs. 11, 12). Prosome in dorsal view somewhat robust ovoid; prosome length less than 2.4 times width. Head slightly truncate in dorsal view, in lateral view with gentle forward slope. Th4 and Th5 usually separate, sometimes partly fused; Th5 lateral corners rounded, not prolonged; Th1-Th4 without lateral spinules. Prosome length about 3½ times urosome. Genital segment slightly wider than long, protruding ventrally one-half depth of rest of urosome; caudal rami length 1½ times width, symmetrical; cluster of spinules on outer dorsal surface. Caudal setae symmetrical; inner setae moderately long. Supra-anal plate without fringe of hairs.

A1 (Fig. 13) exceeding caudal rami by nearly 4 segments; terminal segments (Fig. 149) of moderate length and width. Apparent deviation: I-2s; remainder as Table 4.

A2 Re1 with 1 seta.

Mn palp with inner row of setules on distal anterior surface of B2 and on surface of Ri1. Blade (Fig. 14) with 4 strong, evenly spaced ventral teeth, 4 smaller, closer spaced teeth, and dorsal seta; proximal surface with cluster of spinules.

Mx1 (Fig. 15) gnathobase with 3 proximal setae on posterior surface, without seta on distal anterior surface.

Mx2 (Fig. 16) with small hump on proximal outer edge, armed with spinules, setules, and hairs; outer seta present (not seen on Arctic specimens); posterior surface of lobe-5 base with spines.

Mxp (Fig. 17) B1 without spine-comb; longitudinal row of stiff hairs on midanterior surface; outer distal edge with 2 posterior rows of short setules. Transverse spine-comb of 5-6 short spines present or not on B2. B2 with longitudinal row of stiff hairs. Outer 2 setae on Ri4-5 nude, bladelike, tapering toward each end; spinules on inner edge of Ri5.

P1 (Fig. 18) B1 anterior surface with outer distal row of spinules. B2 inner anterior surface with a few spinules; inner margin with hairs. Re1 anterior surface with outer distal row of spinules; Re2 surface appearing nude; Re3 surface nude. Re1 outer spine usually reaching beyond Re2; Re2 outer spine reaching beyond base of Re3 outer spine. Ri surface nude.

P2 (Fig. 19) B1 surface nude, or with few setules, inner margin with hairs. P3 (Fig. 20) B1 surface with spinules and denticles, inner margin with hairs. P4 (Fig. 21) B1 surface, except for typical transverse row of setules, nude; inner margin with hairs; B2 nude.

Re2 posterior surface on P3 with proximal row of ca. 8 very broad, flat, leaflike spines and distal row of 5-6 denticles; on P4 with proximal row of ca. 7 similar leaflike spines and distal row of 5-6 small spines.

Re3 posterior surface on P2 and P3 without proximal row of spines, but with 2 distal rows of 2-4 small spines; on P4 without surface spines.

P3 Ri3 posterior surface with 2 rows of spines.

Re terminal seta with following number of primary teeth: P2 (31-44); P3 (30-43); P4 (24-35). P2 terminal seta more than 1½ times length of Re3; P3 terminal seta slightly longer than Re3.

Male.—Length 1-1.40 mm (Figs. 27, 28). Prosome anterior irregular in dorsal view, posterior somewhat rounded; in lateral view with gentle forward slope. Ce and Th1 partly fused. Prosome length 2 times urosome. Caudal rami length slightly more than width, symmetrical. Caudal setae as on female.

A1 (Fig. 29) reaching about end of Th4. IV-2s,2e; VIII-2s,2e; XV-1s,1e; XIX-1s,1e; right XX-1s; left XX-1e; remainder as Table 4.

A2 (Fig. 22) as on female except for typical dimorphic characteristics.

Mn blade (Figs. 23, 24) typically reduced, showing some slight variability.

Mx1 gnathobase (Fig. 25) reduced, 3 or 4 sinuate prongs.

Mx2 (Fig. 26) typically reduced; proximal setae

smaller than on female; setae of lobe-5 nude; large setae distal from lobe-5 wider and more coarsely spinulose than on female, especially 1 of terminal 3 setae and largest seta of lobe-6. No spines on lobe-5 base; no outer seta observed.

Mxp (Fig. 30) somewhat reduced; several setae of reduced size, especially on B1-2 and outer edge of Ri4-5, but number as on female. B1 surfaces nude. B2 relatively thinner than on female, with longitudinal row of stiff hairs. Ri5 inner edge without spinules.

P1 similar to female P1 except Re outer spines wider, shorter, and smoother. Ri outer lobe rounded.

P2 similar to female P2 except B1 outer surface with long thin setules, and Re outer spines longer than on female.

P4 (Fig. 31) B1 nude; Ri as on female, except more spines in each row. Re2 posterior surface with row of ca. 8 leaflike spines followed distally by more or less circular patch of ca. 15 small spines; Re3 with ca. 17 denticles in 3 groups on posterior surface; serrations on terminal seta finer than on female, ca. 50 primary teeth.

P5 (Figs. 32, 33) reaching to end of urosome segment 2; biramus, left-handed. Left B1 reaching middle of right B2; left B2 reaching two-thirds length of right Re1. Left leg longest; left Re, including terminal blade, longest; right Ri not much longer than left. Order of length, longest to shortest, of Re segments: left 2, 1, 3; right 1 = 2 = 3. Left Ri reaching one-third length of left Re2; right Ri reaching to right Re3. Probably each Re1 with short, flat seta on outer distal edge (not seen on Arctic specimens). Right Re1-2 more or less fused. Inner edge of left Re1-2 with long hairs. Each Re with 1 small and 1 moderate bladelike terminal setae.

Male stage V.—Length 0.88-0.95 mm. P5 (Fig. 34) biramus, symmetrical. Re 1-segmented with trace of segmentation about one-third length; 2 unequal terminal setae. Ri 1-segmented, thin distal portion reaching about two-thirds length of Re.

Remarks

Sars (1900) did not describe the well-developed spines on the posterior surface of P2-P4 Re, even though the material he examined is as described above. Sars mistakenly illustrated an outer seta on P2 Ri2; his slide (OSLO F6511) only has 1 P2, which was mounted so that the inner seta of Re1 met the Ri at the base of a surface spine, giving the appearance of a fifth seta on Ri2. Sars' slide was remounted and it was seen that there is no outer seta on P2 Ri2 of the holotype or on any other *S. longicornis* studied.

Sars' (1900) description of a male *S. longicornis* was pointed out first by Mrázek (1902) not to be of the male, and later Sars (1903, p. 157) confirmed that it was a *Microcalanus* species. A vial from the Norwegian North Polar Expedition (F2482) labeled by Sars "*Spinocalanus longicornis*" contained only one male *Microcalanus* species; sample 15 (Table 3) also contained, in addition to *S. longicornis*, one male, one male stage V, and two female *Microcalanus* species.

Mrázek (1902) repeated Sars' record of *S. longicornis*. Mrázek also described the male and female of a new species, *S. schaudinni*, which is considered here as conspecific with *S. longicornis*. Mrázek's description provided much of what Sars' lacked, and led Mrázek to believe that the two species were distinct.

Brodsky (1950) was the first to state that *S. longicornis* was probably equivalent to *S. schaudinni*, and at the same time distinct from both *S. abyssalis* Giesbrecht and *S. longicornis/S. abyssalis*.—Sars, 1901, 1903 (see *S. brevicaudatus*). Brodsky reported that the outer spines on P1 Re do not reach the base of the following spines; specimens in the present study had longer spines, and this feature is considered variable.

Farran's (1926) *S. abyssalis* var. *pygmaeus* has been assumed by Park (1970) and Grice (1971) to be equivalent to *S. abyssalis* Giesbrecht. Some of Farran's specimens were examined in the present study (sample 1, Table 3) and were determined to be *S. longicornis*. It is possible, however, that Farran included both species in this variety, since they co-occur in the North Atlantic.

Park's (1970) *S. parabyssalis* holotype was determined to be *S. longicornis*; Park's description and figures of the female are consistent with the above description of *S. longicornis*. The male *S. parabyssalis*, however, is believed to be *S. abyssalis*.

Grice's (1971) figures of *S. parabyssalis* also agree with the description of *S. longicornis*. The references to these figures are correct in his key, but the figure legend transposed the caption for *S. abyssalis* and *S. parabyssalis* (G. Grice, pers. commun.).

Of the material examined in the present study, the suture between Th4 and Th5 was clear on most of the Arctic *S. longicornis* females, and on the two females from sample 1. These segments were partly fused on the *S. parabyssalis* holotype, from sample 55, and on the six females from sample 23.

Mxp B2 spine-comb was present right and left on the specimens in sample 1, and on 4 Arctic specimens; on left but not right on 2 Arctic specimens; absent on the holotype from sample 15, the 6 females from sample 23, and 12 other Arctic specimens.

Distribution

Some records of *S. abyssalis* or *S. abyssalis* var. *pygmaeus* may be based on either or both *S. abyssalis* and *S. longicornis* (see discussion under *S. abyssalis*); these include specimens as short as 0.8-0.83 mm.

Probable or confirmed occurrences of *S. longicornis* are summarized below. Bogorov (1946a) recognized two species, based primarily on size, *S. longicornis* and *S. abyssalis*; presumably the latter was the larger (see *S. elongatus*). Bogorov identified the material

reported by Shirshov (1938). Grice (1962) reported *S. abyssalis* var. *pygmaeus*, which was probably *S. longicornis*. Scotto di Carlo (1968) and Hure and Scotto di Carlo (1968, 1969) reported *S. abyssalis* var. *pygmaeus* which they later (Hure and Scotto di Carlo, 1971) equated with *S. parabyssalis* Park. Hughes' (1968) specimens were examined and found to be *S. longicornis*. G. A. Heron (pers. commun.) identified *S. longicornis* (females, males, and juveniles) from Weather Station "P" in the northeast Pacific, from four 55-m depth intervals between 220 and 440 m; six females were examined in the present study.

Arctic Ocean
- Central: Bogorov (1946a), 10-750 m. —Brodsky (1950, 1957), 25-3,000 m.
- Eurasian Basin: Sars (1900), 100-500 m. —Mrázek (1902), 0-100 m. —Shirshov (1938), 3-1,000 m. —Grice (1962), 110 m.
- Canadian Basin: Bogorov (1946b), 0-300 m. —Brodsky and Nikitin (1955), 0-3,260 m. —Hughes (1968), 25-185 m. —Vidal (1971). —Present study, 80-2,500 m.

Pacific Ocean
- Northeast: von Vaupel-Klein (1970), 0-1,200 m. —Present study, 220-440 m.

Atlantic Ocean
- Northeast: Farran (1926), 200-2,700 m.
- East: Present study.
- Mediterranean Sea: Scotto di Carlo (1968), 200-1,000 m. —Hure and Scotto di Carlo (1968, 1969, 1971), 50-1,000 m. —Grice (1971), 750-1,400 m.
- Caribbean Sea: Park (1970), 200-950 m.

Spinocalanus abyssalis has been reported from the Arctic without size indications: Bernstein (1934) and Khmyznikova (1936) for the Kara Sea; Johnson (1963a) and Minoda (1967) for the Central Arctic; and Jaschnov (1948), repeating the Kara Sea and Sars' Polar Basin records. Jaschnov's figures are copied from Sars' (1901, 1903) figures of *S. brevicaudatus*. These records may represent *S. longicornis*, but they may also include *S. elongatus* or other species.

Norman's (1905) reference to specimens of *S. longicornis* obtained from Sars could be either to Arctic *S. longicornis* or Norwegian *S. brevicaudatus*. Ostenfeld (1909) reported *S. longicornis* from the Atlantic (identified by Farran) and the North Sea (identified by T. Scott); both records could include *S. brevicaudatus*.

Von Vaupel-Klein's (1970) record of a male *S. longicornis* from the northeast Pacific is considered here (see also *S. abyssalis*).

(3. *Spinocalanus schaudinni* Mrázek, 1902)

See *Spinocalanus longicornis* Sars, 1900.

4. *Spinocalanus magnus* Wolfenden, 1904

(Figures 35-42, 150)

Spinocalanus magnus Wolfenden, 1904, p. 118. —Farran, 1905, p. 30-31, pl. 3, fig. 1-12. —Wolfenden, 1906, p. 41-43, pl. 14, fig. 1-5. —van Breemen, 1908, p. 29, fig. 29. —Wolfenden, 1911, p. 216-217, fig. 8; pl. 25, fig. 3-5. —Sars, 1924, 1925, p. 33-34, pl. 9, fig. 8-15. —Rose, 1933, p. 85, fig. 43. —Davis, 1949, p. 22-23, fig. 25-26. —Brodsky, 1950 (part), p. 123-124, fig. 43; "female T" only. —Farran and Vervoort, 1951a, p. 2-3, fig. 2b, g. —Tanaka, 1956, p. 391-392, fig. 15. —Grice, 1971, p. 275-280, fig. 1, 3G-H.

Spinocalanus latifrons Sars, 1907, p. 5.

Spinocalanus heterocaudatus Rose, 1937, p. 151-157, fig. 1-3. —*not* Rose, 1942, p. 315-318, 15 figs.

Spinocalanus pacificus Mori, 1942, p. 568, pl. 14, fig. 1-6.

Spinocalanus spinipes Brodsky, 1950 (part), p. 126-127, fig. 45; male only.

TYPE SPECIMEN: Unknown.

TYPE LOCALITY: Northeast Atlantic, 500-1,800 m.

MATERIAL STUDIED: 2 females (2.77, 2.90 mm), sample 2 (Table 3); 1 female (2.1 mm), sample 27; 2 females (1.98, 2.05 mm), sample 30; 36 females (1.95-2.20 mm, mean = 2.08 mm) and 1 male (1.80 mm), sample 31; 3 females (2.2-2.4 mm), sample 33; 1 female (2.32 mm), sample 34; 6 females (1.87-2.42 mm, mean = 2.10 mm), 3 female stage V (1.85, 1.92, 1.95 mm), and 4 male stage V (1.88, 2.00, 2.00, 2.02 mm), sample 41.

Description

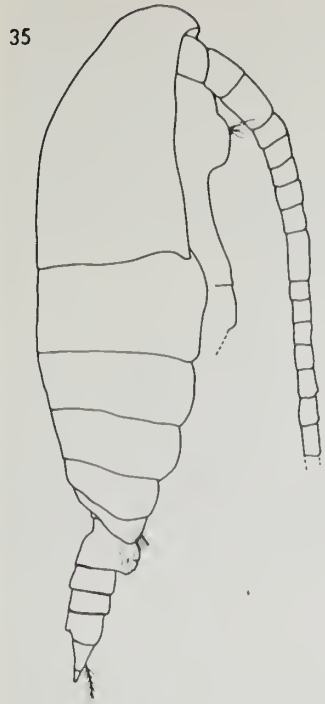
P1 Ri with 3 inner setae; P2 Ri2 with 1 outer seta.

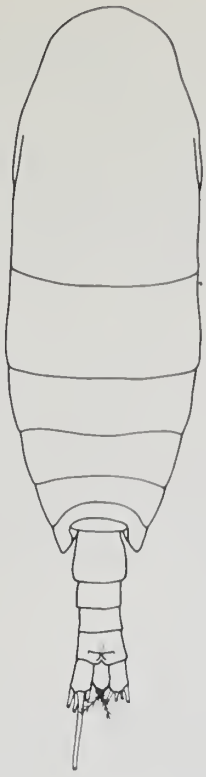
Female.—Length 1.87-3.1 mm (Figs. 35-38). Prosome in dorsal view relatively slender, long ovoid. Head rounded in dorsal view, in lateral view with gentle, uneven forward slope. Th4 and Th5 separate; Th5 lateral corners prolonged, variable, reaching about midgenital segment; projections sometimes more or less closely surrounding genital segment (Fig. 38). Th1-Th4 without lateral spinules. Prosome length 3¼ times urosome. Area of attachment proximal to genital segment without dorsal spinules. Genital segment about as long as wide, protruding ventrally one-half depth of rest of urosome; caudal rami length about 1⅔ times width, left ramus longer and wider than right. Caudal setae also asymmetrical: left terminal seta second from inner, very thick, length exceeding 3 mm.

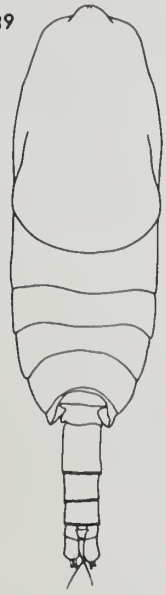
A1 reaching midcaudal rami; terminal segments (Fig. 150) of moderate length and width. Apparent deviations: I-2s; XV-1s; remainder as Table 4.

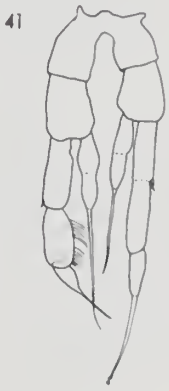
A2 Re1 without setae.

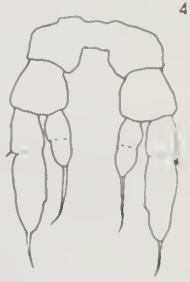
Mn palp without setules on inner distal B2; Ri1











Spinocalanus magnus

Figure 35.—Female, habitus, lateral view; sample 31 (Table 3); scale A.
Figure 36.—Female, habitus, dorsal view; sample 31, scale A.
Figure 37.—Female, habitus, lateral view; sample 41; scale A.
Figure 38.—Female, Th5 and urosome, dorsal view; sample 41; scale A.
Figure 39.—Male, habitus, dorsal view; sample 31; scale A.
Figure 40.—Male, habitus, lateral view; sample 31; scale A.
Figure 41.—Male, P5; sample 31; scale D.
Figure 42.—Male stage V, P5; sample 41; scale D.

with 2 setae and surface setules. Blade damaged in all preparations.

Mx1 gnathobase apparently without anterior distal seta, although very flat spiniform process suggested by some preparations; 4 proximal posterior setae.

Mx2 with moderately strong nude hump on proximal outer edge; outer seta apparently absent; posterior surface of lobe-5 base without spines.

Mxp B1 without spine-comb; transverse row of setules about midlength on anterior surface; distal inner anterior surface with transverse row of stiff hairs; few other spinules and setules over surface. B2 without spine-comb; longitudinal row of stiff hairs on inner edge. Two outer setae on Ri4-5 not fragile, as large as other large terminal setae, fringed with long hairs on inner edge, short hairs on outer edge; no spinules on inner edge of Ri5.

P1 B1 inner edge and surface with few hairs. B2 inner surface and margin with few setules and hairs; outer distal anterior edge with transverse row of small spinules. Re1-2 anterior surface with outer distal row of spinules; Re3 posterior surface without spines. Re1 outer spine barely reaching Re3, although somewhat variable; Re2 outer spine reaching slightly beyond base of terminal spine. Ri inner lobe with row of spinules on anterior surface.

P2-P3 B1 surface nude, inner margin with hairs. P4 B1 surface with proximal row of spinules on posterior surface, in addition to transverse row of setules near base of seta; inner margin without hairs; B2 nude.

P2 Re1 outer spine small, straight, not sharply curved.

Re2 posterior surface on P3-P4 with 1 oblique row of long spines.

Re3 posterior surface on P2-P3 with 1 distal row of short spines; posterior surface on P4 without spines, anterior surface with distal row of small spines.

Ri2 posterior surface on P2 with proximal row of 3-7 small spines, distal row of 6-9 long spines.

P3-P4 Ri3 posterior surface with proximal row of denticles and distal row of long spines.

Re terminal seta with following number of primary teeth: P2 (24-29); P3 (20-25); P4 (24-25).

Male.—Length 1.80-2.43 mm (Figs. 39, 40). Prosome in dorsal view long ovoid; anterior irregular, nearly rectangular; posterior somewhat rounded; in lateral view with gentle forward slope. Ce and Th1 separate; Ce only slightly expanded dorsolaterally. Prosome length 2⅔ times urosome. Anal segment not reduced, two-thirds length of caudal ramus. Caudal rami length 1¾ times width, symmetrical. Caudal setae unknown.

A1 reaching end of caudal rami; segment 1 without cluster of spines or setules; segments 8 and 9 (fused) relatively long; segment 25 not reduced. IV-2s, 1e; VIII-2s, 1e; XV-1s, 1e; XIX-1s, 1e; right XX-0; left XX-1e; remainder as Table 4.

P4 B1 with inner seta reaching mid-B2.

P5 (Fig. 41) biramus, left-handed; reaching nearly to distal edge of urosome segment 3. Left B1 reaching one-third length of right B2; left B2 reaching middle of right Re1. Right leg somewhat longer than left; right Re, including terminal blade, longest; left Ri longest. Order of length, longest to shortest, of Re segments: left 1, 2, 3; right 1 = 2, 3. Left Ri reaching left Re tip; right Ri reaching right mid-Re3. Each Re1 with short flat seta on distal outer edge. Right Re1-2 nearly fused; line of fusion midlength on each Ri. Inner edge of left Re2 with long hairs. Only 1 bladelike terminal seta seen on each Re.

Male stage V.—Length 1.88-2.02 mm. P1 Ri lobe anterior surface with 2 close rows of spinules, upper row ca. 15 short spinules, lower row ca. 7 long spinules. P5 (Fig. 42) biramus, symmetrical. Re 1-segmented; small flat seta just proximal to trace of segmentation about one-third length; 1 flat terminal seta. Ri 1-segmented with midlength trace of segmentation; terminal flat seta nearly reaching Re terminal seta.

Remarks

Wolfenden's (1904) original description of *S. magnus* was very brief and only distinguished it from known species.

Farran (1905) provided the first detailed description; he stated that the setation of the swimming legs agreed with *S. abyssalis,* which it does not. His illustration of P1, however, shows 5 setae on Ri; this was overlooked by Rose (1937) and Grice (1971). Farran mentioned the asymmetry of the caudal rami and setae; the large ramus was incorrectly stated as the right, but correctly shown in his figure.

Wolfenden (1906) provided descriptive information on an Antarctic specimen, which he said agreed closely with northeast Atlantic specimens and those from the Strait of Gibraltar. This description was essentially reprinted in 1911.

Sars (1924, 1925) unfortunately described and illustrated *S. magnus* P1 Ri with only 4 setae. Three of the four samples in which he found this species were from the Mediterranean Sea; this seems to have been overlooked by Sars himself in his summary of distribution, and also by Rose (1933, 1937) and Scotto di Carlo (1968), but not by Massuti (1939). Sars reported that *S. magnus* is found throughout the Bay of Biscay; this is not supported by his data or earlier records. Perhaps he misread "west" for "east" longitude of his eastern stations, placing the three stations in the vicinity of the Bay of Biscay, albeit two on land.

Van Breemen's (1908) description is from Farran. Rose's (1933) and Farran and Vervoort's (1951a) descriptions are from Sars.

Brodsky (1950) included two species in his description of *S. magnus* (see *S. antarcticus*). Only his remarks on and illustration of the North Pacific form apply to *S. magnus.* Brodsky, however, was the first since Wolfenden to point out the existence of two

closely related forms differing in body type; Brodsky suggested that these might be subspecies.

Tanaka (1956) was the first to recognize, and provide descriptive information on, the male of *S. magnus*.

Sars (1907) reported *S. magnus* from the Atlantic and also briefly described a new species, *S. latifrons*, which he later (1924, 1925) equated with *S. magnus*.

Rose (1937) described in detail a new species, *S. heterocaudatus*, from the Bay of Algiers. He seems to have had but one specimen, although the number was not stated. He agreed that it was close to *S. magnus*, with essentially only four differences: *S. heterocaudatus* was characterized by (1) 5 setae on P1 Ri, (2) left caudal ramus with an extraordinarily long and thick second from inner terminal seta, (3) symmetrical (sic) caudal rami, and (4) Th5 lateral corners prolonged to nearly the end of genital segment. There is no doubt that *S. magnus* has 5 setae on P1 Ri, and it also has an enlarged left caudal seta; both of these characteristics were described by Farran (1905) and agree with the present material. The caudal rami might be variable in symmetry (see *S. similis*). The Th5 prolongation is definitely variable, due in part to the contraction of the urosome, although not to the degree shown by Rose; the viewing angle may make the prolongation appear more or less than it is, although Rose's lateral view also indicates a great prolongation. This specimen may have been abnormal, as suggested by Grice (1971). Nearly 1 yr after collecting *S. heterocaudatus*, Rose found *S. magnus* at the same locality, but *S. heterocaudatus* was never again reported. Rose (1942) described a specimen as the male of *S. heterocaudatus*, also from the Bay of Algiers; that this specimen is definitely not in Spinocalanidae has been mentioned by Vervoort (1946).

Mori (1942) described a female stage V *S. magnus* as the adult of a new species, *S. pacificus*. He was aware of the close relationship of the two species, but incorrectly considered *S. magnus* to have 4 setae on P1 Ri, not 5 as did his specimen. Mori's figures essentially agree with female stage V examined in this study: P1 Ri lobe anterior spinules longer than shown by Mori, extending beyond lobe; P2 as shown by Mori with 1 row of spines on Re2-3 and Ri2; P3 with 1 row of spines on Re2-3 and Ri2-3; P4 with 1 row of spines on Re2 and Ri2-3, and no posterior surface spines on Re3. Re3 on P2-P4 proportionally shorter and wider than on adult females. Mori's specimen was 1.9 mm; it was collected near Palao, "accurate positions unknown."

Brodsky (1950) described a female (see *S. horridus*) and a male as a new species, *S. spinipes*. The description of the male is consistent with that of *S. magnus*, except for a shorter, probably left, P5 Ri, which may have been broken. There are only four species of *Spinocalanus* known, including *S. magnus*, with male anal segment not reduced; Brodsky's figure clearly indicates a short, nonreduced anal segment. The body form and size is unlike *S. validus* male; *S. antarcticus* and *S. angusticeps* males have uniramus P5.

Distribution

Except for Arctic records and some records in transition areas, between the Atlantic and the Arctic, and around the Antarctic, records of *S. magnus* are accepted. *Spinocalanus magnus* is very widespread, horizontally and vertically:

Pacific Ocean
- North: Brodsky (1950, 1957), 400-4,000 m. —Minoda (1971), 1,000-2,000 m.
- Northeast: Davis (1949), 1,100-2,300 m. —Fleminger (1967), 0-140 m.
- East: Present study, 0-300 m.
- Central: Wilson (1942), 50-100 m. —Present study, 0-1,000 m.
- Northwest: Brodsky (1950; 1952a, b; 1957), 0-4,000 m. —Tanaka (1953, 1956), 0-1,000 m. —Furuhashi (1961, 1966), 298-3,010 m.
- West: Mori (1942).
- Indo-Pacific: Vervoort (1946), 345-2,500 m.

Indian Ocean
- North: Sewell (1929), 0-360 m.
- West: Grice and Hulsemann (1967), 1,000-4,000 m.
- Southwest: De Decker and Mombeck (1965), 1,000-1,500 m.

Atlantic Ocean
- North: Lysholm and Nordgaard (1921, 1945), 400-1,250 m.
- Northeast: Wolfenden (1904, 1906), 540-1,800 m. —Farran (1905, 1908, 1920, 1926), 0-3,600 m. —Sars (1912; 1924, 1925), 0-3,000 m. —With (1915), 0-1,000 m. —Lysholm and Nordgaard (1945), 300-1,000 m.
- East: Lysholm and Nordgaard (1945), 1,200-3,400 m. —Grice and Hulsemann (1965), 180-5,000 m. —Roe (1972b), 550-960 m.
- Mediterranean Sea: Wolfenden (1906), 0-650 m. —Sars (1907; 1924, 1925), 0-2,300 m. —Rose (1937), 0-400 m. —Scotto di Carlo (1968), below 300 m. —Hure and Scotto di Carlo (1968), below 300 m. —Grice (1971), 850-1,400 m.
- Southeast: Unteruberbacher (1964), 0-300 m.
- West: Grice (1963), 600-1,200 m. —Wheeler (1970), 2,000-4,000 m.
- Caribbean Sea: Park (1970), 500-1,900 m.

Antarctic
- Indian Sector: Wolfenden (1906, 1911), 0-3,400 m.

The records of Pearson (1906) and Massuti (1939) are previous records of Farran and Sars.

Probably *S. magnus* enters the Arctic from the Atlantic, but its distribution there should be investigated further, since the similar *S. antarcticus* is present over a large part of the Arctic. Reports of *S. magnus* from the Greenland Sea (Damas and Koefoed, 1907; repeated by Jespersen, 1939b), 100-1,350 m; Davis Strait (Störmer, 1929), 100-300 m;

West Greenland (Jespersen, 1934), 500-1,500 m; and the Norwegian Sea (Østvedt, 1955), 600-2,000 m, could be either or both species.

The investigation of *S. magnus* in the Antarctic has likewise been hampered by the co-occurrence of the two closely related species. The material of Hardy and Gunther (1935) and Vervoort (1951, 1957, 1965) should be reexamined.

Wilson (1942) combined *S. magnus* from two samples (sample 41, Table 3); the composite did contain *S. magnus* and both stations are considered valid records. The other three samples reported by Wilson to contain *S. magnus* were not located but were collected at intermediate positions. Wilson (1950) reported *S. magnus* from the China Sea, but the sample so labeled did not contain any Spinocalanidae and the record is considered invalid.

Some of Farran's specimens of *S. magnus* are in the collection of the National Museum of Ireland, Dublin (O'Riordan, 1969). The holotype of *S. latifrons* Sars is on slides F5041-F5043, OSLO.

5. *Spinocalanus antarcticus* Wolfenden, 1906

(Figures 43-68, 151, 152)

Spinocalanus antarcticus Wolfenden, 1906, p. 43, pl. 14, fig. 6-9. —Wolfenden, 1911, p. 217-218, fig. 9.
Spinocalanus magnus. —Brodsky, 1950 (part), p. 123-124, fig. 43; not "female T". —Bradford, 1971, p. 18, fig. 28-29. —Vidal, 1971, p. 18, 23, fig. 34-35, 38, 40-41. Not *S. magnus* Wolfenden, 1904.
Spinocalanus? sp. Johnson, 1963a, p. 91-94, fig. 2.

TYPE SPECIMEN: Unknown.
TYPE LOCALITY: Antarctic, Indian Ocean Sector, 1,200 m.
MATERIAL STUDIED: 7 females (2.38-2.56 mm, mean = 2.46 mm), sample 7 (Table 3); 7 females (2.55-2.62 mm, mean = 2.58 mm), sample 9; 9 females (2.52-2.83 mm, mean = 2.66 mm), 1 male (1.80 mm), and 2 male stage V (1.75, 1.90 mm), sample A2 (Table 1); 9 females (2.5-2.75 mm, mean = 2.64 mm), 5 female stage V (1.9-2.1 mm, mean = 2.04 mm), and 3 male stage V (1.7, 1.8, 1.8 mm), sample A4; 2 females (2.60, 2.68 mm) and 3 males (1.83, 1.84, 1.90 mm), sample A5; 6 females (2.50-2.80 mm, mean = 2.59 mm), 3 female stage V (2.0, 2.15, 2.25 mm), and 1 male (1.70 mm), sample A6; 2 males (1.98, 2.05 mm), sample A23; 2 males (2.00, 2.32 mm), sample A27; 6 females (2.60-2.76 mm, mean = 2.67 mm), sample A33; 2 females (2.60, 2.65 mm) and 5 males (1.92-2.09 mm, mean = 1.99 mm), sample A34; 1 male (2.00 mm), sample A36; 7 females (2.76-3.00 mm, mean = 2.84 mm) and 1 male (2.08 mm), sample A48; 2 females (2.75, 2.82 mm), sample A50; 1 male (1.92 mm), sample A51.

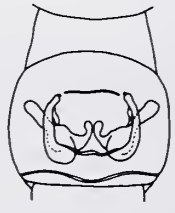
Description

P1 Ri with 3 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 2.25-3.00 mm (Figs. 45, 46). Prosome in dorsal view robust ovoid, in lateral view with abrupt, even forward slope. Th4 and Th5 separate; Th5 lateral corners prolonged, variable, reaching about midgenital segment. Th1-Th4 without lateral spinules. Prosome length 4¼ times urosome. Area of attachment proximal to genital segment with dorsal spinules. Genital segment slightly wider than long, protruding ventrally one-third depth of rest of urosome; genital segment relatively opaque, masking internal structure; genital field (Fig. 43) apparently similar in all *Spinocalanus* species. Supra-anal plate with row of spinules. Caudal rami about as long as wide, left ramus longer and wider than right. Caudal setae also asymmetrical: left terminal seta second

Spinocalanus antarcticus, female

Figure 43.—Genital segment, ventral view; scale C.
Figure 44.—A2; scale C.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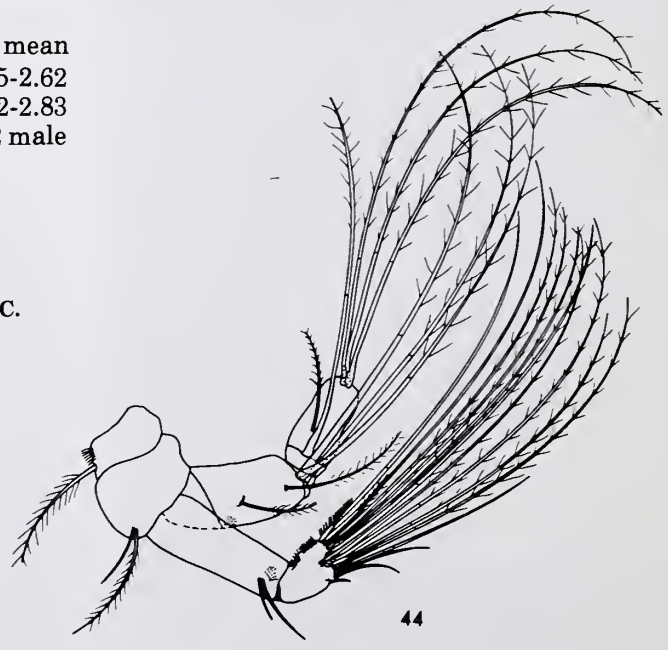
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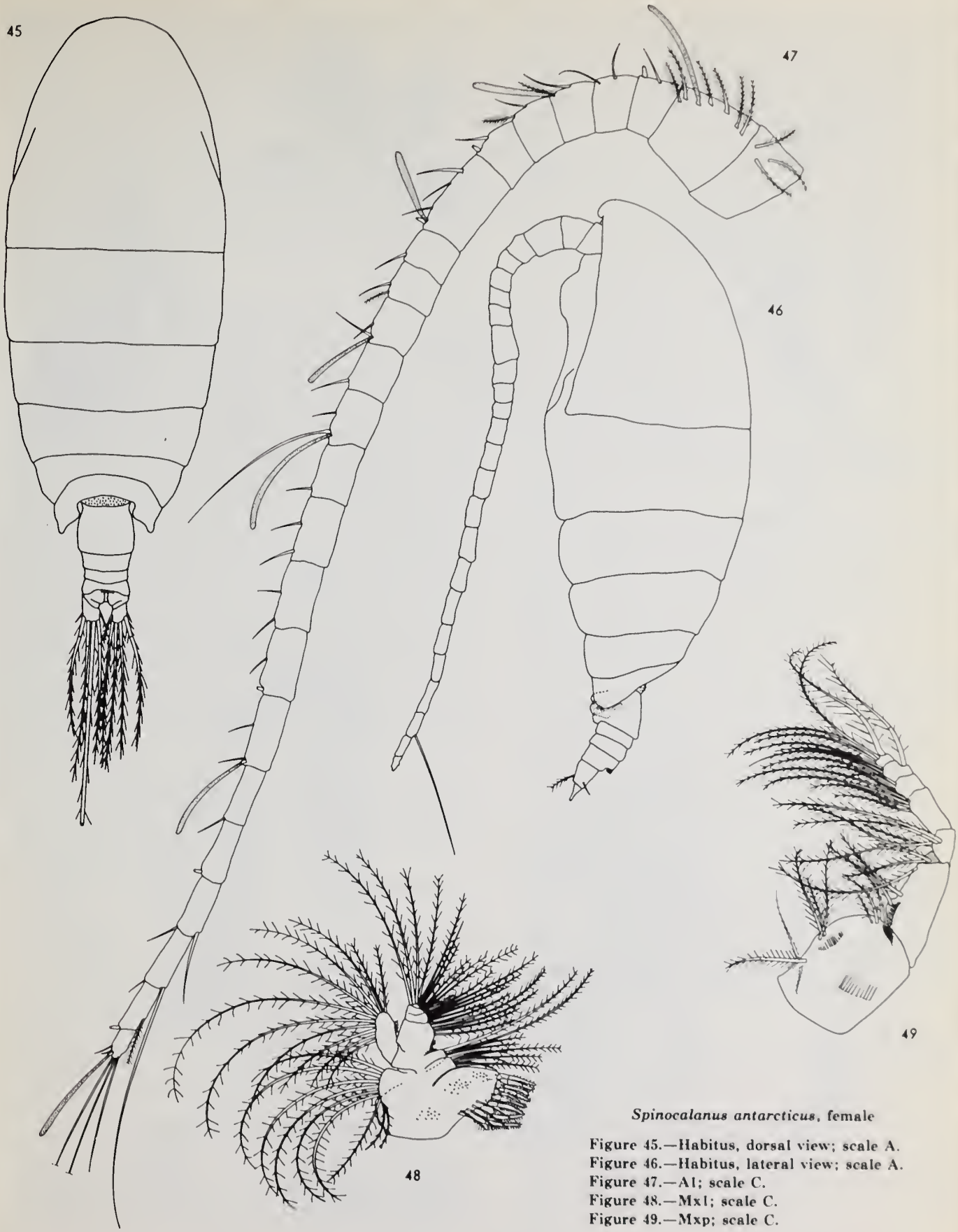
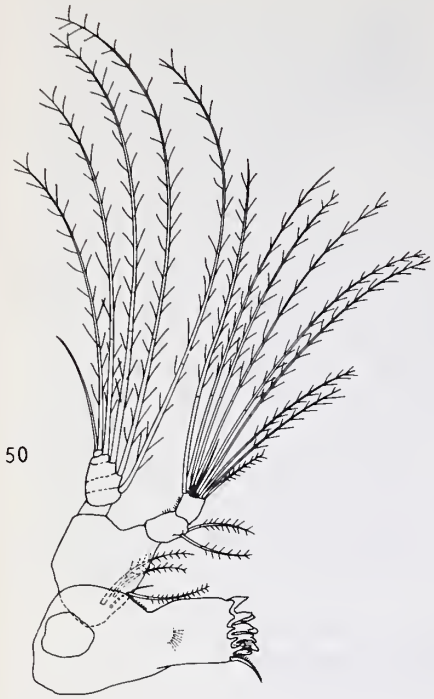
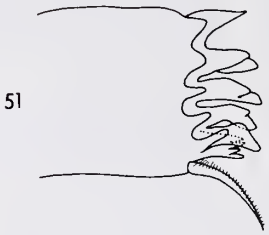
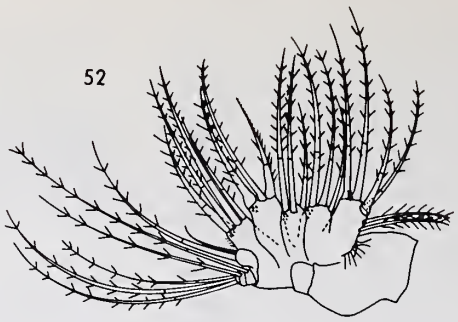


Spinocalanus antarcticus, female

Figure 45.—Habitus, dorsal view; scale A.
Figure 46.—Habitus, lateral view; scale A.
Figure 47.—A1; scale C.
Figure 48.—Mx1; scale C.
Figure 49.—Mxp; scale C.







Spinocalanus antarcticus, female

Figure 50.—Mn; scale C.
Figure 51.—Mn blade; scale F.
Figure 52.—Mx2; scale C.
Figure 53.—P1; scale C.
Figure 54.—P2; scale C.
Figure 55.—P3; scale C.
Figure 56.—P4; scale C.

from inner, very thick, length exceeding 6 mm. Small outer (sixth) seta on some specimens.

A1 (Fig. 47) reaching beyond caudal rami by about 3 segments; terminal segments (Figs. 151, 152) of moderate length and width. Apparent deviation: XV-1s; remainder as Table 4.

A2 (Fig. 44) Re1 without setae.

Mn (Fig. 50) palp without setules on inner distal B2; Ri1 with 2 setae and surface setules; Ri2 apparently with 10, rather than 11, setae. Blade (Fig. 51) with cluster of setules on midanterior surface; cutting edge with 5 large teeth, outermost 1-pointed, others more or less 2-pointed; 1 near-dorsal 4-pointed process; and dorsal seta.

Mx1 (Fig. 48) gnathobase with 4 proximal posterior setae and small distal anterior seta.

Mx2 (Fig. 52) with moderately strong nude hump on proximal outer edge; outer seta apparently absent; posterior surface of lobe-5 base without spines.

Mxp (Fig. 49) B1 without spine-comb; transverse row of setules about midlength on anterior surface; longitudinal row of spinules midlength on inner anterior surface; distal inner anterior surface with row of stiff hairs. B2 without spine-comb; short longitudinal row of stiff hairs on inner edge. Ri4-5 outer setae not fragile, as large as other large terminal setae, fringed with long hairs on inner edge, short hairs on outer edge; no spinules on inner edge of Ri5.

P1 (Fig. 53) B1 inner edge and surface with few setules. B2 inner surface with setules, margin with hairs; outer distal anterior edge with transverse row of small spinules. Re1-2 anterior surface with outer distal row of spinules; Re3 posterior surface with 6-8 short spines. Re1 outer spine reaching Re3, although length variable; Re2 outer spine reaching beyond base of terminal spine. Ri inner lobe with row of spinules on anterior surface.

P2 (Fig. 54)-P3 (Fig. 55) B1 surface nude, inner margin with hairs. P4 (Fig. 56) B1 surface with proximal row of spinules on posterior surface, in addition to transverse row of setules near base of seta; inner margin without hairs; B2 nude.

P2 Re1 outer spine small, straight, not sharply curved.

Re2 posterior surface on P3-P4 with 1 oblique row of long spines.

Re3 posterior surface on P2-P3 with 1 distal row of spines; posterior surface of P4 without spines, anterior surface with distal row of small spines.

P2 Ri2 posterior surface with proximal row of few denticles, distal row of long spines.

P3-P4 Ri3 posterior surface with proximal row of denticles (sometimes minute) and distal row of long spines.

Re terminal seta with following number of primary teeth: P2 (36-41); P3 (32-40); P4 (31-44).

Male.—Length 1.66-2.32 mm (Figs. 57, 58). Prosome in dorsal view robust ovoid; anterior and posterior irregular, somewhat rectangular; in lateral view with abrupt, even forward slope. Ce and Th1 separate. Ce not expanded dorsolaterally. Prosome length 2½ times urosome. Anal segment not reduced, two-thirds length of caudal ramus. Caudal rami length 1½ times width, left ramus slightly larger than right. Inner caudal seta reduced; left terminal seta second from inner somewhat longer than right; small outer (sixth) seta present.

A1 (Fig. 59) reaching beyond caudal rami by 2-3 segments; segment 1 without cluster of spines or setules; segments 8 and 9 (fused) relatively long; segment 25 not reduced. IV-2s, 1e; VIII-2s, 1e; XV-1s, 1e; XIX-1s, 1e; right XX-1s; left XX-1e; remainder as Table 4.

Mn blade (Fig. 60) reduced; 5 more or less blunt teeth, 3-pointed near-dorsal process, 1 short, nude dorsal seta.

Mx1 gnathobase (Fig. 61) reduced; 6 outer blunt processes, 3 proximal moderately sharp, nude setae.

Mxp (Fig. 62) similar to that on female, perhaps with loss or marked reduction of some B1-2 setae; Ri4-5 setae nude, outer 2 and terminal setae markedly reduced.

P1 (Fig. 63) B1 inner surface with few short hairs; B2 inner margin with long hairs. Ri surface nude. Re1 outer spine reaching beyond midlength of Re2, nearly to base of Re2 outer spine; Re3 surface without spines.

P2 (Fig. 64)-P3 (Fig. 65) as on female, except P2 Ri2 without proximal spinules.

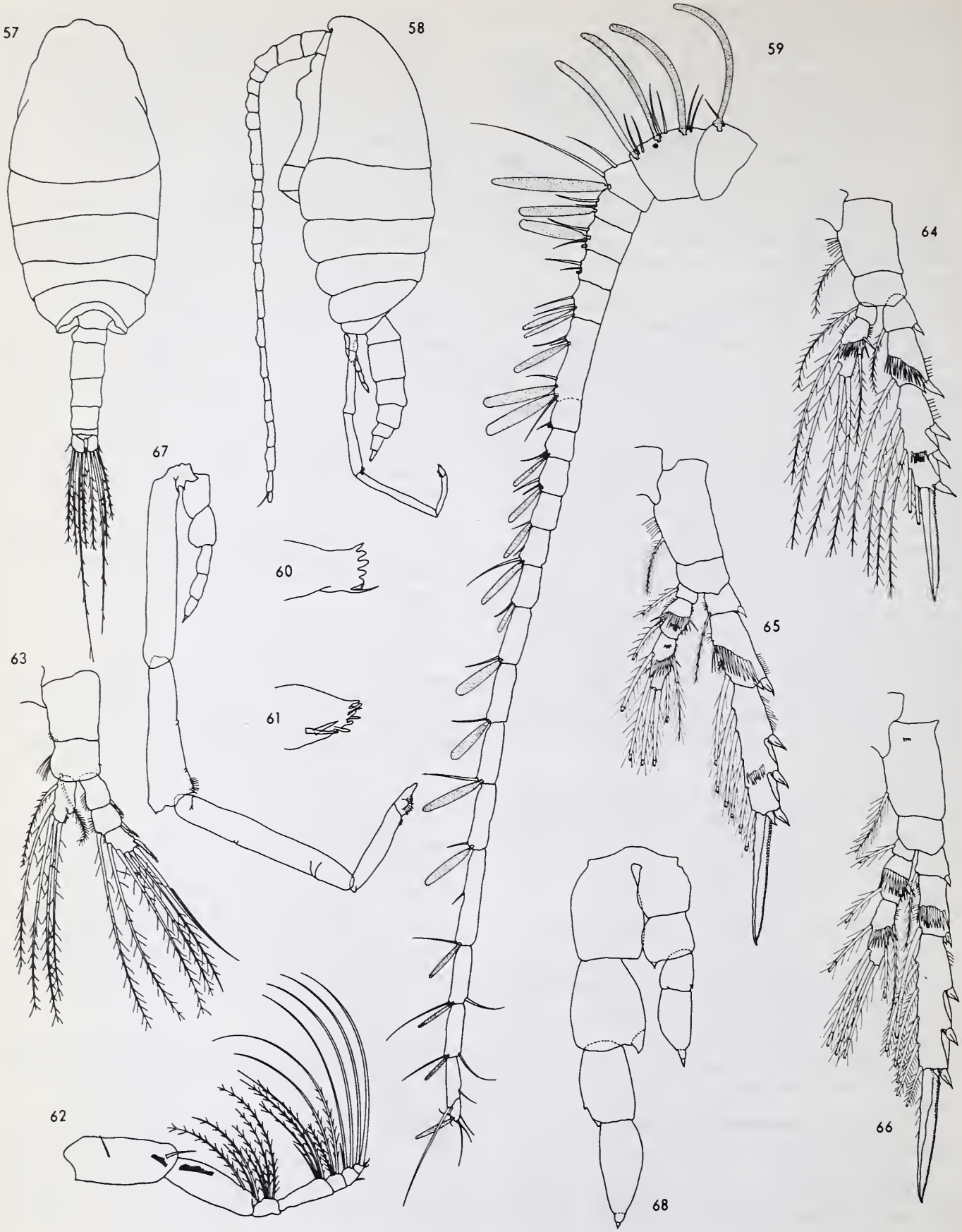
P4 (Fig. 66) B1 inner seta shorter than on female, reaching beyond Ri1. Ri3 proximal posterior surface with or without few minute or small spines, distal surface with 1 row of long spines. Re3 without distal anterior row of spines. P4 otherwise as on female.

P2-P4 Re terminal seta with finer and more numerous (ca. 50) teeth than on female.

P5 (Fig. 67) left-handed; uniramus, very asymmetrical. Right leg reaching midurosome segment 3; left leg greatly exceeding length of urosome. Right leg not reaching end of left B1. Order of length, longest to shortest, of (Re) segments: left and right 1, 2, 3. Left Re2 about one-half length of Re1. Right leg segments nude, except short, flat terminal seta. Left B2 with inner distal cluster of hairs; small distal cluster of hairs on Re2; Re3 short, with central cluster of hairs, terminating in digitiform process.

Male stage V.—Length 1.7-1.90 mm. P1 Ri lobe anterior surface with 2 close rows of spinules, upper row ca. 15 short spinules, lower row ca. 7 long spinules.

P5 (Fig. 68) left-handed; uniramus, asymmetrical; right leg reaching left Re1. B2 with inner distal spiniform process. Re 2-segmented, with perhaps trace of small terminal segment; Re1 with outer distal spiniform process; Re with short, flat terminal process.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Remarks

Wolfenden (1906), who also first described the closely related *S. magnus*, differentiated between that species and *S. antarcticus* because of the different body types. This is easily seen when the two species are side-by-side, as they were in Wolfenden's Antarctic collections. However, this difference in form is not so easily defined. Wolfenden's figures indicate only a slight prolongation of Th5; actually it is as prolonged as on *S. magnus*. His lateral figure (1911) indicates some hesitancy in this regard since it is clearly altered. The unusual male, described by Wolfenden (1906), probably led several workers (e.g., Vervoort, 1957) to discount, at least in part, the validity of *S. antarcticus*. Wolfenden's description of the male agrees with that given above, except in one feature: Wolfenden stated, and illustrated, that *right* P5 was longest; this could be an error, since left P5, when the male is viewed dorsally, actually curves out to the *right* of the specimen, while the shorter right leg is obscured. No males from the Antarctic were found for comparison during the present study.

Brodsky (1950) described two body types of *S. magnus*, which he suggested might be subspecies. Only his Arctic specimens were *S. antarcticus*, while those from the North Pacific were *S. magnus*. His figure of P3 appears to be a composite of P3 and P4.

The description and illustrations by Bradford (1971) are consistent with those of *S. antarcticus*. Bradford's specimens (sample 9, Table 3) were found also to agree in all respects with the description of *S. antarcticus*.

Distribution

There are several records of *S. magnus* from high latitudes that may be of *S. antarcticus* (see also *S. magnus*): especially the Arctic records of Grice (1962) in the Eurasian Basin (110 m); Grainger (1965) in the Canadian Basin (0-500 m); and Dunbar and Harding (1968) in the Canadian Basin (0-2,000 m).

Several records of *S. magnus* are interpreted or confirmed as *S. antarcticus*. Some of Farran's (1929) specimens from the Antarctic (sample 7, Table 3) were found to be *S. antarcticus*. Brodsky and Nikitin's (1955) records of *S. magnus* from the Arctic Canadian Basin are accepted as *S. antarcticus*. Johnson (1963a) and Minoda (1967) both indirectly indicated the presence of male *S. antarcticus*, so that their records of *S. magnus* are also interpreted as *S. antarcticus*.

The distribution of *S. antarcticus* is summarized below:

Arctic Ocean
- Central: Brodsky (1950), 0-400 m or more.
- Eurasian Basin: Minoda (1967), 0-850 m.
- Canadian Basin: Brodsky and Nikitin (1955), 0-below 1,000 m. —Johnson (1963a), 0-2,000 m. —Vidal (1971). —Present study, 140-2,500 m.

Antarctic
- Pacific Sector: Farran (1929), 0-1,750 m. —Bradford (1971), 0-1,000 m.
- Indian Sector: Wolfenden (1906, 1911), 1,200 m.

Although there have been no records of *S. antarcticus* outside of the Arctic and Antarctic, the possibility of a continuous distribution should not be overlooked. Perhaps *S. antarcticus* inhabits greater depths in midlatitudes, or perhaps it has not been recognized in midlatitude collections. A specimen of *Spinocalanus* sp. Johnson was reported by Wheeler (1970) from the northwest Atlantic, but this is probably a male of *S. angusticeps*.

(6. *Spinocalanus major* Esterly, 1906)

See *Spinocalanus brevicaudatus* Brodsky, 1950.

(7. *Spinocalanus latifrons* Sars, 1907)

See *Spinocalanus magnus* Wolfenden, 1904.

8. *Spinocalanus hirtus* Sars, 1907

Spinocalanus hirtus Sars, 1907, p. 5-6. —Sars, 1925, p. 32-33.
Spinocalanus hirtipes. —Sars, 1924, lapsus calami, pl. 9, fig. 1-7.

TYPE SPECIMEN: Holotype, female, on Slide F5039, OSLO.
TYPE LOCALITY: East Atlantic, 0-5,000 m.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Spinocalanus antarcticus, male

Figure 57.—Habitus, dorsal view; scale A.
Figure 58.—Habitus, lateral view; scale A.
Figure 59.—A1; scale C.
Figure 60.—Mn blade; scale F.
Figure 61.—Mx1 gnathobase; scale F.
Figure 62.—Mxp; scale C.
Figure 63.—P1; scale C.
Figure 64.—P2; scale C.
Figure 65.—P3; scale C.
Figure 66.—P4; scale C.
Figure 67.—P5; scale C.
Figure 68.—Stage V, P5; scale D.

Female.—Length 2.12-3.58 mm. Prosome in dorsal view long ovoid, head rounded; in lateral view with gentle, then abrupt, forward slope. Th4 and Th5 separated by fine suture; Th5 lateral corners slightly prolonged, margins with stiff hairs. Prosome length 3⅓ times urosome.

Mxp details unknown.

P1-P4 B1 densely covered with short hairs. P2 Re2 posterior surface possibly with two rows of spines. P2-P3 Re3 posterior surface with several small spines along length.

Male.—Unknown.

Remarks

Sars (1907) briefly described this species from a single female; more information on the same specimen, with illustrations, was added later (1924, 1925). Sars' figure of P1 is lacking an inner seta on Re3.

Only three other specimens have been reported: Vervoort (1946), one female from the Indo-Pacific, 653-1,000 m; Grice and Hulsemann (1965), two females from the eastern North Atlantic, near the type locality, 3,000-4,750 m.

9. *Spinocalanus spinosus* Farran, 1908

(Figure 84)

Spinocalanus spinosus Farran, 1908, p. 27, pl. 1, fig. 10. —Rose, 1933, p. 86, fig. 46. —Farran and Vervoort, 1951a, p. 2-3, fig. 4b, d-e. —Park, 1970, p. 485-487, fig. 37-42.

TYPE SPECIMENS: Syntypes, females, BM 1908.7.6.7-10.

TYPE LOCALITY: Northeast Atlantic, 600-1,800 m.

MATERIAL STUDIED: 3 females (1.67, 1.85, 1.87 mm), sample 5 (Table 3); 2 females (1.90, 1.90 mm), sample 31.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.67-2.0 mm. Prosome in dorsal view somewhat robust ovoid, head slightly truncate; in lateral view with abrupt forward slope. Th4 and Th5 separate; Th5 lateral corners rounded, not prolonged. Th1-Th4 with lateral spinules, number decreasing posteriorly, approximately even right and left. Prosome length 2⅔-3 times urosome. Genital segment about as long as wide, protruding ventrally about one-third depth of rest of urosome; long hairs on ventral surface of urosome segments 1-3. Caudal rami length 1½ times width, symmetrical.

A1 broken in specimens examined.

A2 Re1 with 2 setae; smaller seta easily detached.

Mx2 with moderate, setule-covered hump on proximal outer edge; outer seta present; posterior surface of lobe-5 base without spines.

Mxp B1 without spine-comb; strong transverse spine-comb on B2. Ri4-5 outer setae nude, bladelike, tapering toward each end; spinules on inner edge of Ri5.

P1 (Fig. 84) B1 outer surface with few thin spinules; inner margin with hairs. B2 anterior surface with few thin spinules and setules. Outer distal anterior surface of Re1-2 with row of spinules. Posterior surface of Re3 with ca. 4 spines. Ri inner anterior surface with row of thin spinules about midlength.

Male.—Unknown.

Remarks

Farran (1908) briefly characterized *Spinocalanus spinosus* by describing the lateral spinules on Th1-Th4. This differentiated *S. spinosus* from the species known up to that time. Since then, several closely related species have been described (*S. horridus*, *S. usitatus*, *S. hoplites*, and *S. oligospinosus*) which seem to be distinguishable essentially by the presence or absence of spines on the base of Mx2 lobe-5; the presence and size, or absence of a transverse spine-comb on Mxp B1; the distribution of lateral spinules; body size, and to some extent body shape. Specimens of all of these "species" have been examined in the present study and these characteristics are described for each. They appear to be consistent and no transition forms have been observed. The only described male is assigned to *S. horridus*; if these named-species with spinulose prosomes are valid, there must be four undescribed males. The co-occurrence of these species hampers the interpretation of records of *S. spinosus*.

Rose's (1933) description is from Farran (1908). Farran and Vervoort (1951a) illustrated Mx2 without spines on the base of lobe-5, consistent with Farran's specimens from sample 5 (Table 3). Farran and Vervoort assigned some records of *S. horridus* to *S. spinosus*, but the two species are considered distinct in the present study (see *S. horridus*).

Some records of very large "*S. spinosus*" (e.g., Farran, 1929; Tanaka, 1956; Grice and Hulsemann, 1965, part) are interpreted as records of *S. horridus*. Vervoort (1946) reported two female *S. spinosus*; he stated that the Mxp of both was as described by Wolfenden (1911) for *S. horridus*, i.e., with B1 transverse spine-comb. Therefore, the larger (2.40 mm) specimen is considered in the present study to be *S. horridus*, while the smaller (1.80 mm) is considered *S. usitatus*.

Park (1970) did not describe *S. spinosus* Mx2, but the Mxp of his specimens was described as without B1 spine-comb, consistent with the above description. Park illustrated P2-P4; P1 is illustrated in the present study (Fig. 84).

Distribution

Accepted records of *S. spinosus* are:

Pacific Ocean
  Central: Present study, 0-1,000 m.
Atlantic Ocean
  Northeast: Farran (1908, 1920, 1926), 180-1,800 m.
  Caribbean Sea: Park (1970), 505-1,000 m.

Probable records, at least in part, of *S. spinosus* are: Grice (1963), Grice and Hulsemann (1965), Wheeler (1970), and Roe (1972b) in the North Atlantic; and De Decker and Mombeck (1965) and Grice and Hulsemann (1967) in the Indian Ocean.

Some of Farran's specimens of *S. spinosus* are in the collection of the National Museum of Ireland, Dublin (O'Riordan, 1969).

10. *Spinocalanus horridus* Wolfenden, 1911

(Figures 69-83, 153)

Spinocalanus horridus Wolfenden, 1911, p. 216, fig. 7; pl. 25, fig. 1-2. —Park, 1970, p. 491, fig. 66-70.
Spinocalanus abyssalis. —Tanaka, 1937 (part), p. 253-254, fig. 4a-c; female only. —Minoda, 1971 (part), p. 11, fig. 30(3), 32(1), 33(2); 1.95-2.2 mm only. Not *S. abyssalis* Giesbrecht, 1888.
Spinocalanus stellatus Brodsky, 1950, p. 125-126, fig 44. —von Vaupel-Klein, 1970, p. 8-10, fig. 1b-f.
Spinocalanus spinipes Brodsky, 1950 (part), p. 126-127, fig. 45; female only.
Spinocalanus dorsispinosus Brodsky, 1950, p. 129, fig. 48.
Spinocalanus sp.? Brodsky, 1950 (part), p. 130-131, fig. 50; female only.
Spinocalanus longispinus Brodsky, 1950, p. 131, fig. 51. —Vidal, 1971, p. 18, 23-24, fig. 42-45, 58-59.
Spinocalanus spinosus. —Tanaka, 1956, p. 390-391, fig. 14. Not *S. spinosus* Farran, 1908.

TYPE SPECIMEN: Unknown.
TYPE LOCALITY: South Atlantic, 0-1,200 m.
MATERIAL STUDIED: 3 females (2.23-2.30 mm), sample 38 (Table 3); 2 females (2.10, 2.12 mm), sample 58; 1 female (2.12 mm), sample 59; 1 female (2.28 mm) and 1 male (2.10 mm), sample A2 (Table 1); 1 male (2.1 mm) and 1 male stage V (1.95 mm), sample A4; 2 males (2.18, 2.25 mm), sample A5; 1 male stage V (1.97 mm), sample A6; 1 male (2.28 mm), sample A21; 2 females (2.48, 2.52 mm) and 1 male (2.32 mm), sample A23; 4 females (2.28-2.48 mm, mean = 2.36 mm), sample A24; 1 male (2.24 mm), sample A33; 1 female (2.36 mm), sample A40; 1 female (2.36 mm), sample A41; 1 female (2.32 mm), sample A42; 1 female (2.36 mm), sample A45; 2 females (2.32, 2.58 mm) and 1 male (2.24 mm), sample A48.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.95-3.0 mm (Figs. 69, 70). Prosome in dorsal view slightly robust, elongate ovoid; head rounded with slight anterior protuberance. Prosome in lateral view with irregular, gentle forward slope. Th4 and Th5 separate; Th5 lateral corners rounded, not prolonged. Th1-Th4 with lateral spinules, number decreasing posteriorly; right side sometimes completely devoid of spinules (Arctic specimens), or spinule distribution may be approximately even right and left (Caribbean specimens). Prosome length 2⅔ times urosome. Genital segment somewhat longer than wide, protruding ventrally about one-half depth of rest of urosome; hairs on ventral surface of genital segment and probably urosome segment 2. Caudal rami length 1½ times width, symmetrical.

A1 exceeding caudal rami by 1-2 segments; terminal segments (Fig. 153) slightly elongate. Apparent deviation: I-2s; remainder as Table 4.

A2 Re1 with 2 setae.

Mn palp with central and distal cluster of long setules on anterior surface; Ri1 surface with setules.

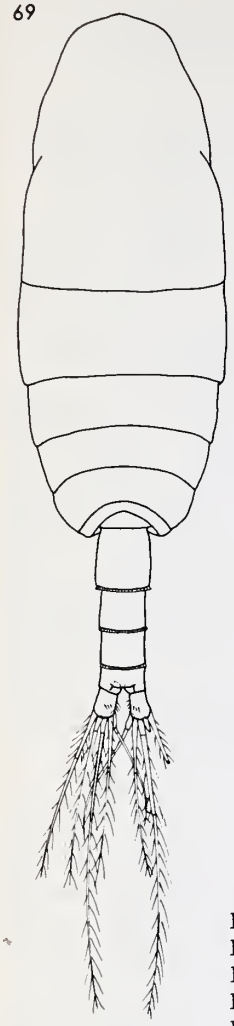
Mx1 gnathobase (Fig. 71) with cluster of spines and 4 setae on proximal posterior surface; distal anterior surface with thin spinule; small cluster of setules near distal outer margin.

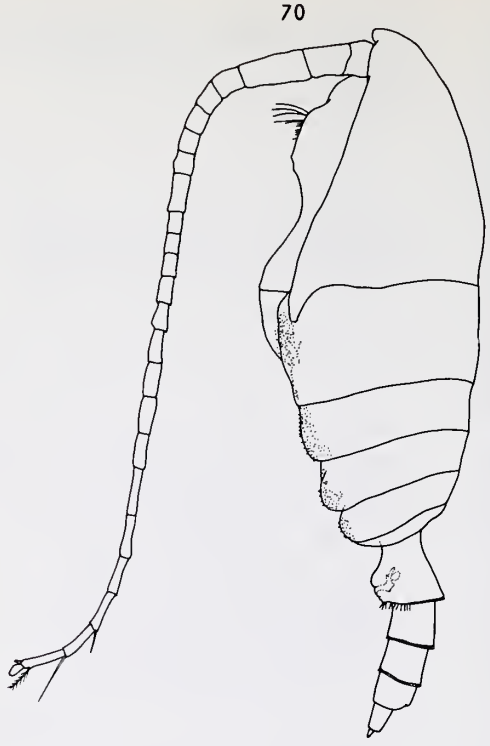
Mx2 (Fig. 72) with small setule-covered hump on proximal outer edge; outer seta present; posterior surface of lobe-5 base without spines. Lobe-4 distal posterior seta stout, with row of close-set spines (Fig. 72 showing only alternate spines). Lobe-5 distal posterior seta spinulose, with slightly widened opening at tip of seta.

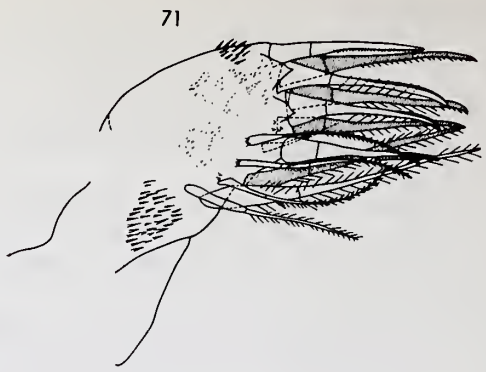
Mxp (Fig. 73) B1 with strong transverse spine-comb on outer midmargin; irregular oblique rows of spines on central and distal anterior surface. One specimen with spine-comb only on left B1. B2 with strong transverse spine-comb about one-third length on outer margin; longitudinal row of spinules on inner margin. Ri1 and Ri5 with inner row of thin spinules. Ri4-5 outer setae nude, bladelike, tapering toward each end.

P1 (Fig. 74) B1-2 surface with setules and hairs, inner margin with hairs. Re1-2 outer distal anterior surface with row of spinules. Posterior surface of Re3 with 5-6 spines. Ri inner anterior surface with row of thin spinules about midlength.

P2 (Fig. 75) B1 outer surface with 3-4 rows of setules; hairs and setules on inner margin. P3 (Fig. 76) B1 surface with 1 inner and 3-4 outer rows of spines; inner margin with hairs. P4 (Fig. 77) B1 inner surface with several patches of long setules, outer surface with

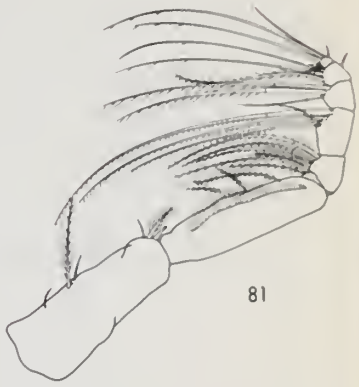






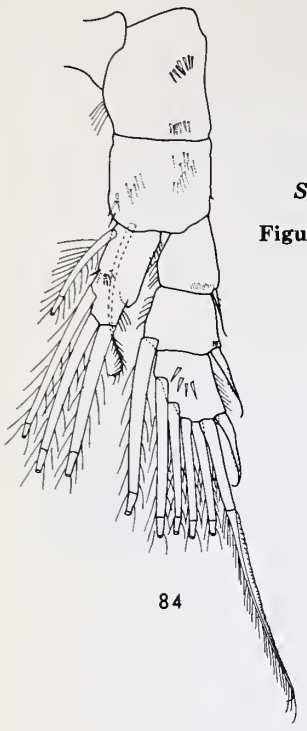
Spinocalanus horridus, female

Figure 69.—Habitus, dorsal view; scale A.
Figure 70.—Habitus, lateral view; scale A.
Figure 71.—Mx1 gnathobase; scale F.
Figure 72.—Mx2; scale D.
Figure 73.—Mxp; scale C.
Figure 74.—P1; scale C.



Spinocalanus horridus

Figure 75.—Female, P2; scale C.
Figure 76.—Female, P3; scale C.
Figure 77.—Female, P4; scale C.
Figure 78.—Male, habitus, dorsal view; scale A.
Figure 79.—Male, habitus, lateral view; scale A.
Figure 80.—Male, Mn blade; scale F.
Figure 81.—Male, Mxp; scale C.
Figure 82.—Male, P5; scale C.
Figure 83.—Male stage V, P5; scale D.



Spinocalanus spinosus, female

Figure 84.—P1; sample 5 (Table 3); scale D.

3-4 rows of spines. B2 inner surface with cluster of thin setules.

P2 Re3 with 2 distal rows of short spines on posterior surface.

P3 Re2 with midlength oblique row of strong spines and distal row of denticles. Re3 with 3 evenly spaced rows of short spines. Ri3 with 2 rows of strong spines.

P4 Re2 with midlength oblique row of strong spines and distal row of smaller spines. Re3 with 3 evenly spaced rows of spines, proximal spines longest, distal spines shortest.

Re terminal seta with following number of primary teeth: P2 (30-36); P3 (28-33); P4 (29-32).

Male.—Length 2.0-2.9 mm (Figs. 78, 79). Prosome anterior irregular in dorsal view, posterior somewhat rectangular; in lateral view with gentle forward slope. Ce and Th1 partly fused. Prosome length 1¾ times urosome. Caudal rami about as long as wide.

A1 reaching end of prosome; segment 1 with conspicuous cluster of setules on anterodorsal surface. IV-2s, 2e; VIII-2s, 2e; XV-2s, 1e; XIX-1s, 1e; right XX-0; left XX-1e; remainder as Table 4.

Mn B2 without distal setules; 2 short setae on inner margin. Ri1 surface setules longer than on female. Segmentation and setation of Re and Ri as on female. Blade (Fig. 80) reduced; ventral tooth in some specimens larger than figured.

Mx1 very fragile, gnathobase reduced to 1-2 small spines on knob.

Mx2 not robust; short, thin outer seta. Some inner setae of reduced size, but probably number as on female.

Mxp (Fig. 81) with reduced size of setae; relatively fragile. Ri4-5 outer setae short and flat; spinules on inner edge of Ri5 as on female.

P1 B1 surface without setules, but hairs longer than on female. B2 surface without setules, inner margin hairs shorter than on female. Re3 posterior surface spines relatively longer than on female.

P2 B1-2, Ri, and Re3 as on female. Re2 with circular patch of spines on posterior surface. Terminal spine with ca. 60 primary teeth.

No specimens observed with P3 Re2-3; remaining segments as on female.

No specimens observed with P4 Re2-3. B1 without setules on inner surface; inner seta reaching beyond Ri1; remaining segments a on female.

P5 (Fig. 82) biramus, left-handed; reaching nearly to end of urosome segment 2. Left B1 reaching one-third to one-half length of right B2; left B2 reaching middle of right Re1. Left and right legs about equal; right Re, including moderately long, flat terminal seta, longest; left and right Ri about equal. Order of length, longest to shortest, of Re segments: left 1 = 2, 3; right 2, 1, 3. Each Re1 with short, flat seta on distal outer edge. Inner edge of left Re2-3 with hairs. Each Re3 with 2 unequal, bladelike terminal setae. Ri imperfectly 2-segmented; left Ri reaching middle of left Re3; right Ri reaching middle of right Re3. Each Ri with long bladelike extension.

Male stage V.—Length 1.95-1.97 mm. Left side of Th2-Th3 with spinules (Arctic specimens).

P5 (Fig. 83) biramus, symmetrical. Re imperfectly 2-segmented; small flat seta on distal edge of Re1; Re2 with 2 small flat terminal setae. Ri 1-segmented, reaching nearly one-half length of Re, with small flat terminal seta.

Remarks

Wolfenden's (1911) original description of *S. horridus* included a figure of Mxp which clearly indicates a transverse spine-comb on B1. Park (1970) likewise illustrated Mxp with spine-comb on B1. These are the only two investigators who have described this species under this name.

Tanaka (1937) described one female *S. abyssalis*, which, except for lateral prosomal spinules, which Tanaka did not mention, agrees with the description of *S. horridus* given above. The prosomal spinules are not particularly conspicuous unless viewed with proper lighting; perhaps also, other populations, besides the Arctic specimens of the present study, have spinules only on one side, and this characteristic might then not be noticed. The male described by Tanaka is considered as *S. brevicaudatus*. Brodsky (1950) recognized that Tanaka's specimens were not *S. abyssalis* Giesbrecht. Minoda (1971) reported large (1.95-2.2 mm) *S. abyssalis* from the Bering Sea; his illustration of Mxp indicates a transverse spine-comb on B1, and the scale to which it was drawn indicates

its origin in the larger specimens, probably *S. horridus*.

Tanaka's (1956) description of *S. spinosus* is consistent with that of *S. horridus* given above. The large size and transverse spine-comb on Mxp B1 are not characteristic of *S. spinosus*.

Brodsky's (1950) descriptions of two new species from the northwestern Pacific, *S. stellatus* (female and male) and *S. spinipes* (female only), are consistent with that of *S. horridus* except for lateral prosomal spinules on female, which Brodsky did not mention. Brodsky (1952a) said that *S. spinipes* was more transparent than *S. stellatus*. The male of *S. spinipes* is considered *S. magnus*.

Brodsky (1950) described an additional new species, *S. dorsispinosus*, based on a male from the northwestern Pacific. Brodsky's description is consistent with that of male *S. horridus* except for the presence of a group of spines "on dorsal side of head." Perhaps these spines are present on males of other *Spinocalanus* species, as well as *S. horridus*, but are extremely fragile or only present for a short time. A similar feature was noticed in some male *Mimocalanus sulcifrons*, but not in any other species studied, including *S. horridus*.

Brodsky's (1950) description of *S. longispinus* from the central Arctic was based, in part at least, on an abnormal specimen. His illustration of P4 indicates an inner seta on B2 (never normally present) and many spines on Ri1 (normally nude in *Spinocalanus* species). Aside from this, his remarks and other figures are consistent with the description of *S. horridus* female, except for lateral prosomal spinules, not mentioned by Brodsky. Specimens reported by Vidal (1971) to be *S. longispinus* were examined (sample 38, Table 3) and found to be equivalent in all respects to other Arctic specimens of *S. horridus*.

Distribution

Records of large *S. spinosus* by Farran (1929), cited by Vervoort (1965); Vervoort (1946); Johnson (1963a); and Grice and Hulsemann (1965; part, up to 2.7 mm) are considered as records of *S. horridus*. Probably *S. spinosus* reported by Furuhashi (1961, 1966) and Minoda (1967) are also *S. horridus*. Records of *S. horridus* and its synonyms are summarized below:

Arctic Ocean
- Central: Brodsky (1950), 400-2,500 m.
- Eurasian Basin: Minoda (1967), 0-850 m.
- Canadian Basin: Brodsky and Nikitin (1955), 100-3,800 m. —Johnson (1963a), 0-2,000 m. —Dunbar and Harding (1968), 500-2,000 m. —Vidal (1971). —Present study, 500-2,500 m.

Pacific Ocean
- North: Brodsky (1957), 100-200 m. —Minoda (1971), 95-2,000 m.
- Northeast: von Vaupel-Klein (1970), 0-1,200 m.
- Northwest: Tanaka (1937, 1953, 1956), 0-1,200 m. —Brodsky (1950; 1952a, b; 1957), 200-4,000 m. —Furuhashi (1961, 1966), 425-3,010 m. —Minoda (1971), 160-1,800 m.
- Indo-Pacific: Vervoort (1946), 1,385-1,900 m.

Atlantic Ocean
- Northeast: Grice and Hulsemann (1965), 500-4,000 m.
- South: Wolfenden (1911), 0-1,200 m.
- Caribbean Sea: Park (1970), 509-1,900 m.

Antarctic
- Pacific Sector: Farran (1929), 0-1,000 m.
- Atlantic Sector: Hardy and Gunther (1935), 1,000-2,000 m.

(11. *Spinocalanus giesbrechti* Brady, 1918)

Spinocalanus giesbrechti Brady, 1918, p. 17-18, pl. 8, fig. 21-25.

TYPE SPECIMENS: The Hancock Museum, Newcastle-upon-Tyne, England.
TYPE LOCALITY: Antarctic, Pacific Sector; surface?

Remarks

Vervoort (1951; p. 9-10, 70) studied the type specimens of *S. giesbrechti* and, because of their poor condition, was unable to correctly identify the specimens. Vervoort stated that "the description is so vague and the figures are so bad that I am not even certain if the form is a *Spinocalanus* at all." Brady's male specimen could not have been an adult; P1 could not be of Spinocalanidae; the P4 appears abnormal; P5 is not from a *Spinocalanus* species. The female could not have been a Spinocalanidae.

Since the type material is now useless, it may never be known what species *S. giesbrechti* represents, but Brady's description is definitely not of any *Spinocalanus* species.

12. *Spinocalanus validus* Sars, 1920

Spinocalanus validus Sars, 1920, p. 2. —Sars, 1924, 1925, p. 29-30, pl. 7, fig. 1-15. —Rose, 1933, p. 85, fig. 44. —Grice and Hulsemann, 1967, p. 21, fig. 28-31.

TYPE SPECIMENS: Syntypes, females (4.50 mm), Musée Océanographique de Monaco (Belloc, 1960); on slides F5035-F5036, OSLO.
TYPE LOCALITY: Northeast Atlantic, 0-1,400 m.
MATERIAL STUDIED: 1 male (4.4 mm), sample 44 (Table 3); 1 female (3.7 mm), sample 51.

Description

P1 Ri with 3 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 3.7-4.7 mm. Prosome in dorsal view slightly robust ovoid. Head somewhat truncate in dorsal view, in lateral view with abrupt forward slope. Th4 and Th5 separate; Th5 lateral corners prolonged, reaching to or slightly beyond midgenital segment (Sars, 1924, fig. 15). Th1-Th4 without lateral spinules. Prosome length 4⅓ times urosome.

A1 incomplete on specimen examined; A1 scarcely exceeding length of prosome, according to Sars.

Mxp without spine-comb on B1-2. Ri4-5 outer setae missing on specimen studied. Ri5 inner edge without spinules.

P1 as shown by Sars, without posterior surface spines on Re3.

P2-P4 B1 surface very setulose, as shown by Sars; specimen examined lacked Re2-3 and Ri. P2 Re1 outer spine small, straight, not sharply curved.

Male.—Length 4.4-5.08 mm. Prosome anterior irregular in dorsal view, posterior somewhat rounded; in lateral view with fairly abrupt forward slope. Ce and Th1 partly fused. Prosome length slightly over 2 times urosome. Anal segment not reduced, two-thirds length of caudal ramus.

A1 incomplete on specimen studied. Mxp with thick, not expanded, hirsute terminal setae; Ri4-5 with reduced outer setae. Ri5 inner edge without spinules.

P1 Re1 outer spine very wide, straight; no posterior surface spines on Re3.

P2-P3 Re and Ri missing on specimen examined. P4 B1 without inner seta; outer surface with proximal setules and distal spines. P4 Re missing. P4 Ri2 posterior surface with 1 proximal row and 1 distal cluster of spines; Ri3 with 2 clusters of spines.

P5 biramus, about as described by Grice and Hulsemann (1967), except perhaps longest basal segments on left (left-handed) rather than right. Anterior/posterior slope of distal B2 edges suggesting this possibility; however, orientation should be reexamined in situ. Each Re with small bladelike terminal seta in addition to long terminal seta shown by Grice and Hulsemann.

Remarks

Sars (1920) briefly described *S. validus*; his record of finding the species at "Stn. 1851" must have been an error, since *S. validus* is not on that station's list of species, and the station is not mentioned in 1925.

Rose's (1933) description and records are repeated from Sars.

Grice and Hulsemann (1967) briefly described the male of *S. validus*, but they also found females (unpublished records); a male is in the USNM (113512) and was examined in the present study.

Distribution

There have been only three additional reports of *S. validus*, all of which are summarized below:

Pacific Ocean
  Indo-Pacific: Vervoort (1946), 653-1,000 m.
Indian Ocean
  West: Grice and Hulsemann (1967), 350-2,000 m.
Atlantic Ocean
  Northeast: Sars (1920; 1924, 1925), 0-1,400 m. —Grice and Hulsemann (1965), 1,500-4,000 m. —Vives (1970), 300-700 m.

13. *Spinocalanus angusticeps* Sars, 1920

(Figure 85)

Spinocalanus angusticeps Sars, 1920, p. 3. —Sars, 1924, 1925, p. 30-31, pl. 8, fig. 1-9. —Farran and Vervoort, 1951a, p. 2-3, fig. 3a-b, d. —Tanaka, 1956, p. 392-394, fig. 16.
Spinocalanus longipes Tanaka, 1956, p. 394-395, fig. 17. —Grice and Hulsemann, 1967, p. 21, fig. 26-27.
Spinocalanus sp. —Wheeler, 1970, p. 9, fig. 23-26.
Not *Spinocalanus*? sp. Johnson, 1963a.

TYPE SPECIMENS: Syntypes, females (2.10 mm), Musée Océanographique de Monaco (Belloc, 1960); on slides F5037, F5047, OSLO.
TYPE LOCALITY: Northeast Atlantic, 0-2,000 m.

***Spinocalanus angusticeps*, female**

Figure 85.—P3; sample 13; scale C.

MATERIAL STUDIED: 1 female (2.14 mm), sample 13 (Table 3); 1 female (on slide), sample 14; 1 male (1.60 mm), sample 50.

Description

P1 Ri with 3 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.98-2.33 mm. Prosome in dorsal view long, slender ovoid; anterior tapering toward slightly truncate head. In lateral view with uneven, gentle forward slope. Th4 and Th5 separate; Th1-Th4 without lateral spinules; Th5 lateral corners protruding about one-third length of genital segment (somewhat more than shown by Sars, 1924, fig. 1). Prosome length slightly more than 4 times urosome. Genital segment as long as wide; protruding ventrally one-third depth of rest of urosome. Caudal ramus length slightly more than width. Caudal setae symmetrical; inner terminal seta omitted in Sars' figure.

A1 unknown; broken in all described specimens. [Sars (1925) stated that A1 must be longer than the body, but his figure shows A1 broken at segment 21 next to distal edge of Th1, so that a complete A1 would probably not extend beyond Th4.]

A2 Re1 without setae, as shown by Sars.

Mx2 without spines on base of lobe-5.

Mxp about as shown by Sars, except 4 setae on Ri2 and only 4 on Ri5. B1 without spine-comb; transverse row of short spinules on distal inner edge. B2 without spine-comb; longitudinal row of stiff long hairs on inner edge.

P1 as shown by Sars, except typical short, thin, outer seta on B2 about two-thirds distal; row of spinules on distal outer anterior surface of Re1-2; no spines on Re3 surface.

P2 as shown by Sars, except distal outer anterior spinules on Re2; Re1 outer spine forming strongly bent hook; no surface spines on Re3, terminal seta with 30-32 primary teeth.

P3 (Fig. 85) Ri only shown by Sars. B1 with several outer and inner surface spines; inner margin with hairs. Re2 posterior surface with irregular cluster of spines; Re3 posterior surface with 2 distal clusters of small spines; terminal seta with 31 primary teeth.

P4 incomplete on specimens studied; B1 with setules, not spinules, in position shown by Sars.

Male.—Length 1.59-1.76 mm. Prosome in dorsal view robust ovoid, anterior and posterior irregularly rounded; in lateral view with abrupt forward slope. Ce and Th1 separate; Ce not expanded dorsolaterally. Prosome about 2⅔ length of urosome. Anal segment not reduced, one-half length of caudal ramus.

A1 described by Tanaka (1956), typical left-handed appendage; length unknown. Segment 25 not reduced.

P1 as figured by Wheeler (1970), except typical outer seta on B2, and Ri lobe with 1-3 terminal points. Re1 outer spine short, reaching slightly beyond midlength of Re2.

P2 Re1 outer spine typical, not forming strongly bent hook.

P4 B1 without inner seta.

P5 essentially uniramus, left-handed; similar to that on *S. antarcticus* male except rudimentary left Ri. Left Re2 nearly equaling length of Re1.

Remarks

Tanaka (1956) described a new species, *S. longipes*, for one male taken in a sample with three female *S. angusticeps*. The similarity of P5 to *S. antarcticus* male P5, and the 3 inner setae on P1 Ri on *S. angusticeps* female (male otherwise unknown) and *S. longipes* (sample 50, Table 3) definitely relates *S. longipes* to the group including *S. angusticeps*, *S. antarcticus*, *S. magnus*, and *S. validus*. Males have been assigned to the latter three species, and *S. longipes* is considered in the present study to be the male of *S. angusticeps*. *Spinocalanus longipes* has also been reported by Grice and Hulsemann (1967), who found female *S. angusticeps* in adjacent areas. Wheeler (1970) reported one male *Spinocalanus* sp. Johnson; Wheeler's specimen lacked Re on the longest P5, which he said was the *right*. Wheeler's figure of P5 suggests a rudimentary Ri; the figure of P1 essentially agrees with male P1 described above, with short Re1 outer spine. Wheeler reported female *S. angusticeps* from the sample which contained this male.

Distribution

Records of *S. angusticeps* are summarized below:

Pacific Ocean
  Northwest: Tanaka (1953, 1956), 0-1,000 m.
  Southwest: Present study, 0-1,000 m.
Indian Ocean
  West: Grice and Hulsemann (1967), 750-2,000 m.
Atlantic Ocean
  Northeast: Sars (1920; 1924, 1925), 0-2,000 m.
  East: Grice and Hulsemann (1965), 450-3,000 m. —Roe (1972b), 660-950 m.
  Northwest: Grice (1963), 700-1,200 m. —Wheeler (1970), 2,000-4,000 m.

(14. *Spinocalanus caudatus* Sars, 1920)

See *Spinocalanus oligospinosus* Park, 1970.

(15. *Spinocalanus abyssalis* var. *pygmaeus* Farran, 1926)

See *Spinocalanus longicornis* Sars, 1900.

(16. *Spinocalanus heterocaudatus* Rose, 1937)

See *Spinocalanus magnus* Wolfenden, 1904.

(17. *Spinocalanus pacificus* Mori, 1942)

See *Spinocalanus magnus* Wolfenden, 1904.

(18. *Spinocalanus stellatus* Brodsky, 1950)

See *Spinocalanus horridus* Wolfenden, 1911.

(19. *Spinocalanus spinipes* Brodsky, 1950)

Female, see *Spinocalanus horridus* Wolfenden, 1911. Male, see *S. magnus* Wolfenden, 1904.

(20. *Spinocalanus pseudospinipes* Brodsky, 1950)

See *Spinocalanus brevicaudatus* Brodsky, 1950.

21. *Spinocalanus similis* Brodsky, 1950

(Figures 86-97, 154)

Spinocalanus similis Brodsky, 1950, p. 128-129, fig. 47.

Spinocalanus similis var. *profundalis* Brodsky, 1955 (part), p. 185-187, fig. 1g; male only.

TYPE SPECIMEN: Unknown.

TYPE LOCALITY: Northwest Pacific, 1,000-4,000 m.

MATERIAL STUDIED: 2 females (1.08, 1.15 mm), sample 30 (Table 3); 4 females (1.03-1.24 mm, mean = 1.12 mm) and 2 males (1.53 mm), sample 31.

Description

P1 Ri with 2 inner setae; P2 Ri2 with no outer seta.

Female.—Length 1.03-1.5 mm (Figs. 86, 87). Prosome in dorsal view robust ovoid. Head rounded in dorsal view; in lateral view with irregular, gentle forward slope. Th4 and Th5 separate; Th5 lateral corners slightly prolonged; Th1-Th4 without lateral spinules. Prosome length slightly more than 3 times urosome. Genital segment slightly wider than long, protruding ventrally one-half depth of rest of urosome; caudal rami about as long as wide; right ramus sometimes larger than left (Brodsky, 1950). Caudal setae incomplete on specimens examined. Supra-anal plate without fringe of long hairs.

A1 exceeding caudal rami by about 1 segment; terminal segments (Fig. 154) of moderate length and width. Apparent deviation: I-2s; remainder as Table 4.

A2 Re1 with 1 seta.

Mx1 gnathobase with 4 proximal setae thick, about one-half thickness of strong outer setae; probably thin seta distal from cluster of long spinules on midanterior surface; posterior surface with several clusters of long and short spinules and spines.

Mx2 with outer seta; posterior surface of lobe-5 base with spines.

Mxp (Fig. 88) with transverse spine-comb on midouter B1; longitudinal row of stiff, short hairs on midanterior surface; proximal and distal row of denticles on posterior surface. B2 with strong transverse spine-comb and longitudinal row of stiff hairs. Ri4-5 outer setae nude, bladelike, tapering toward each end; spinules on inner edge of Ri5.

P1 (Fig. 89) B1 with few setules and spinules on distal surface; inner margin nude. B2 anterior and posterior inner surface with hairs and setules. Re1-2 anterior surface with outer distal row of spinules; Re3 posterior surface with 3-4 spines (present material) or nude (Brodsky, 1950). Re outer spines reaching beyond base of following spines. Ri surface nude.

P2 (Fig. 90)-P3 (Fig. 91) B1 outer surface with 3 rows of spines; inner surface with setules, inner margin with hairs. P4 (Fig. 92) B1 outer anterior surface with few short spines; inner surface with few long hairs. P2-P4 B2 nude.

Re2 posterior surface on P3-P4 with proximal row of 12 "wide lamellar spines" (Brodsky, 1950), but apparently not as wide as those on *S. abyssalis* or *S. longicornis* (Brodsky, fig. 47); distal row of few small spines.

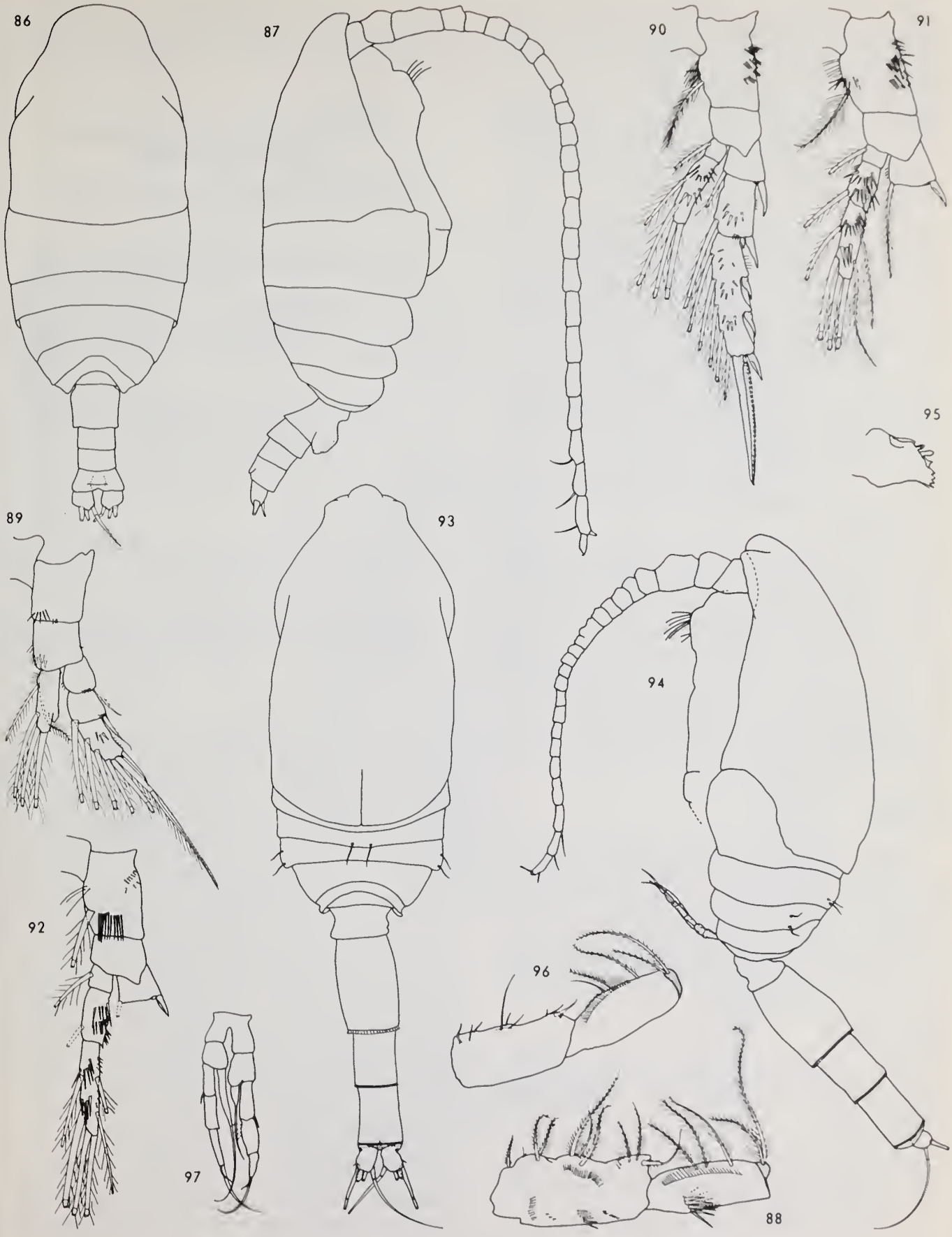
Re3 posterior surface on P2-P4 with 3 rows of 4-5 spines (Brodsky, 1950, for P3-P4).

P3-P4 Ri3 posterior surface with proximal row of thin spines, distal row of few larger spines.

Male.—Length 1.4-1.6 mm (Figs. 93, 94). Prosome anterior irregular in dorsal view, posterior somewhat rectangular; in lateral view with gentle forward slope. Ce and Th1 separate. Prosome length 1⅔ times

Spinocalanus similis

Figure 86.—Female, habitus, dorsal view; sample 30 (Table 3); scale B.
Figure 87.—Female, habitus, lateral view; sample 30; scale B.
Figure 88.—Female, Mxp B1-2; sample 30; scale D.
Figure 89.—Female, P1; sample 30; scale D.
Figure 90.—Female, P2; sample 30; scale D.
Figure 91.—Female, P3; sample 30; scale D.
Figure 92.—Female, P4; sample 30; scale D.
Figure 93.—Male, habitus, dorsal view; sample 31; scale B.
Figure 94.—Male, habitus, lateral view; sample 31; scale B.
Figure 95.—Male, Mn blade; sample 31; scale G.
Figure 96.—Male, Mxp B1-2; sample 31; scale D.
Figure 97.—Male, P5; sample 31; scale D.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urosome. Caudal rami length 1½ times width, symmetrical. Caudal setae incomplete on specimens examined; short stiff hair on outer margin of rami may be remnant of sixth seta.

A1 reaching about end of prosome, *left* segment 20 merging with segment 21, typical of *right-handed* males. IV-2s, 2e; VIII-2s, 2e; XV-1s, 1e; XIX-1s, 1e; right XX-1e; left XX-0; remainder as Table 4.

Mn blade (Fig. 95) reduced; 7-8 short, subequal teeth; short dorsal seta.

Mxp (Fig. 96) B1-2 without spine-combs, setae of reduced size; longitudinal row of stiff hairs on B2. Outer setae nude, reduced; no spinules on inner edge of Ri5; large inner setae of last segments not inflated.

P1 as on female, except Re outer spines shorter and wider; spinules not seen on Re1-2 distal anterior surface; 4-5 spines on Re3 posterior surface.

P2-P3 B1 with longer, thinner, and more numerous spines than on female; B2, Re1, and Ri1 as on female. P2 Ri2 proximal row of spines of decreasing length from outer to inner edge, distal row of 5-6 large spines. Re2-3 lacking on specimens examined.

P4 B1 nude inner surface and margin; few short setules on outer proximal surface, and minute spinules on outer distal anterior surface. Re1 and Ri1 as on female.

P5 (Fig. 97) biramus, *right-handed*: reaching middle of urosome segment 2. Right B1 reaching one-third length of left B2; right B2 reaching middle of left Re1. Right and left legs about equal; left Re, including terminal blade, slightly longer than right; left Ri longer than right. Order of length, longest to shortest, of Re segments: left 3, 1 = 2; right 1 = 2, 3. Left Ri reaching two-thirds length of Re long terminal seta. Right Ri reaching middle of right Re3. Each Re1 with short, flat seta on distal outer edge. Inner edge of right Re2 with long hairs. Each Re with 1 small and 1 moderate bladelike terminal setae.

Remarks

Brodsky (1950) did not describe Mxp nor P2 Ri; the present specimens agree with Brodsky's description of *S. similis* except for the symmetry of caudal rami and the posterior surface spines on P1 Re3.

Brodsky (1955) briefly redescribed the male *S. similis* as *S. similis* var. *profundalis*; the female which he included in this variety is considered in the present study as *S. brevicaudatus*.

Distribution

The only published records of *S. similis* are by Brodsky, and the distribution of this species is summarized below:

Pacific Ocean
Northwest: Brodsky (1950; 1952a, b; 1955, 1957), 0-8,500 m.
Central: Present study, 0-1,000 m.

Brodsky (1957) also indicated that *S. similis* was found in "abyssal and lower bathypelagic" layers in the Bering Sea.

(22. *Spinocalanus dorsispinosus* Brodsky, 1950)

See *Spinocalanus horridus* Wolfenden, 1911.

(23. *Spinocalanus* sp.? Brodsky, 1950) (*Spinocalanus abyssalis.* —Tanaka, 1937)

Female, see *Spinocalanus horridus* Wolfenden, 1911. Male, see *S. brevicaudatus* Brodsky, 1950.

(24. *Spinocalanus longispinus* Brodsky, 1950)

See *Spinocalanus horridus* Wolfenden, 1911.

25. *Spinocalanus elongatus* Brodsky, 1950

(Figures 98-113, 155)

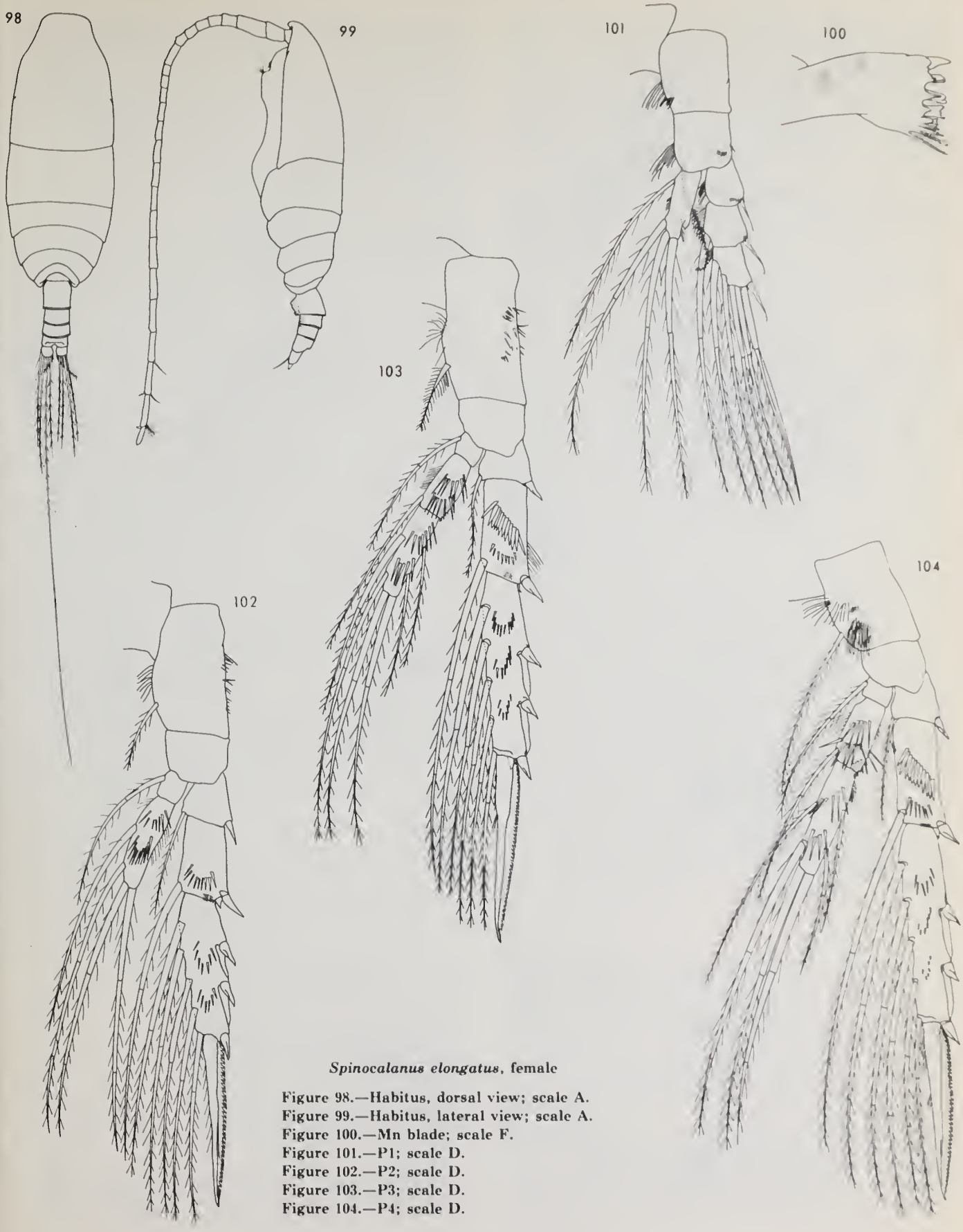
Spinocalanus elongatus Brodsky, 1950 (part), p. 132-133, fig. 52; female and "male variant" but not "male." —Vidal, 1971, p. 18, 23, fig. 46-47, 50-51, 56-57.

TYPE SPECIMEN: Unknown.
TYPE LOCALITY: Central Arctic Ocean, 50 m.
MATERIAL STUDIED: 8 females (1.50-1.80 mm, mean = 1.65 mm), sample A1 (Table 1); 6 females (1.58-1.80 mm, mean = 1.64 mm), sample A2; 20 females (1.50-1.80 mm, mean = 1.61 mm), 1 female stage V (1.37 mm), and 2 males (1.45, 1.55 mm), sample A4; 9 females (1.58-1.70 mm, mean = 1.64 mm), 1 female stage V (1.54 mm), and 1 male (1.62 mm), sample A5; 1 female stage V (1.70 mm), 11 female stage IV and 2 male stage IV (1.15-1.23 mm), 12 stage III (0.8-1.05 mm), and 2 male stage V (1.48, 1.53 mm), sample A6; 2 males (1.60 mm), sample A20; 1 male (1.68 mm), sample A21; 1 male (1.56 mm), sample A23; 7 males (1.60-1.76 mm, mean = 1.66 mm), sample A24; 2 males (1.60, 1.64 mm), sample A27; 1 female (1.68 mm), sample A31; 2 males (1.70, 1.72 mm), sample A33; 12 females (1.50-1.72 mm, mean = 1.61 mm) and 1 male (1.68 mm), sample A48.

Description

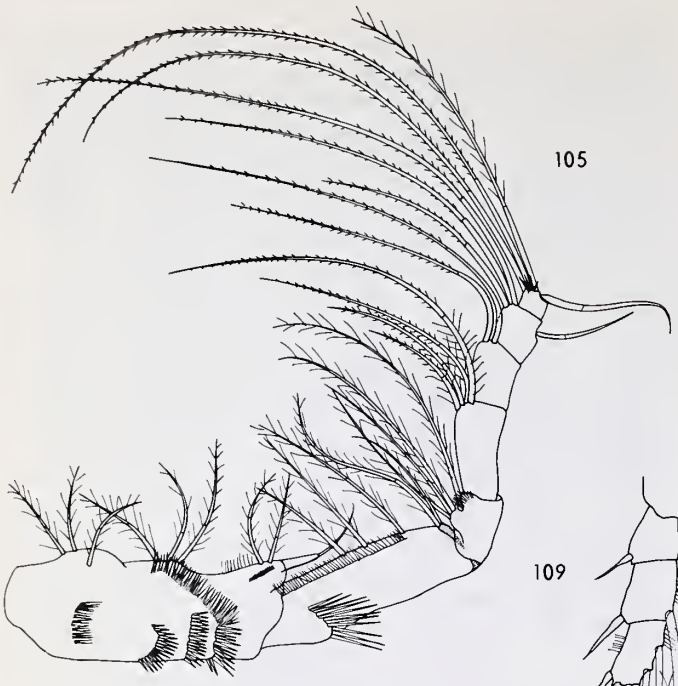
P1 Ri with 2 inner setae; P2 Ri2 with no outer seta.

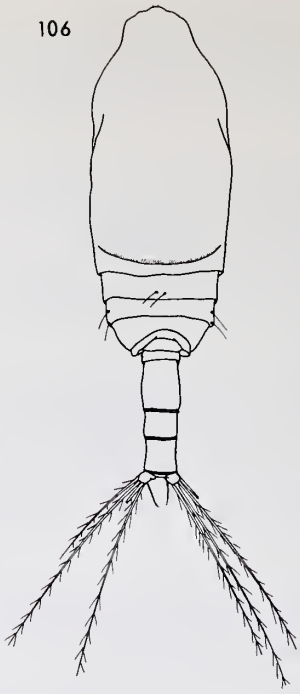
Female.—Length 1.50-1.80 mm (Figs. 98, 99). Prosome in dorsal view ovoid, head somewhat trun-

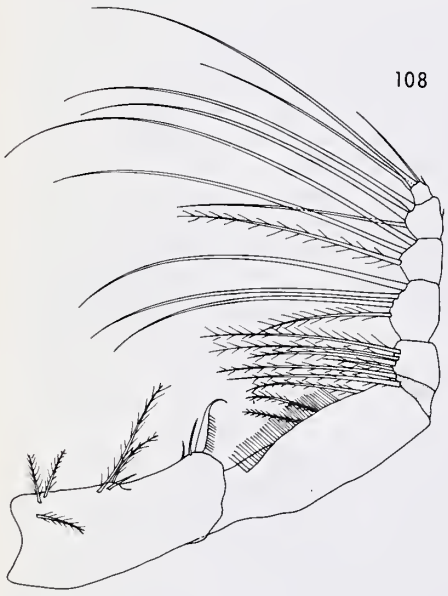


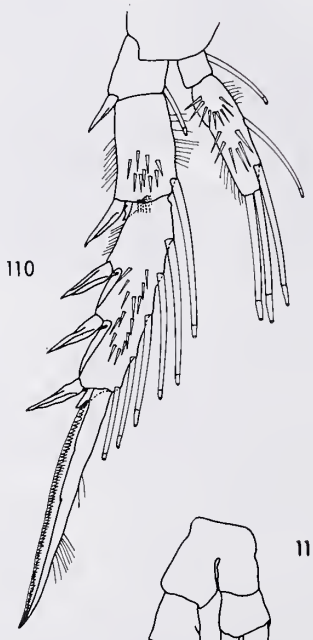
Spinocalanus elongatus, female

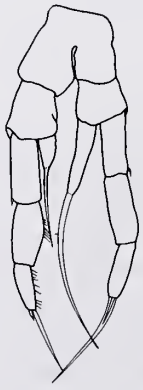
Figure 98.—Habitus, dorsal view; scale A.
Figure 99.—Habitus, lateral view; scale A.
Figure 100.—Mn blade; scale F.
Figure 101.—P1; scale D.
Figure 102.—P2; scale D.
Figure 103.—P3; scale D.
Figure 104.—P4; scale D.











Spinocalanus elongatus

Figure 105.—Female, Mxp; scale D.
Figure 106.—Male, habitus, dorsal view; scale A.
Figure 107.—Male, habitus, lateral view; scale A.
Figure 108.—Male, Mxp; scale D.
Figure 109.—Male, P1, left; scale D.
Figure 110.—Male, P2, left; scale D.
Figure 111.—Male, P3, left; scale D.
Figure 112.—Male, P5; scale D.
Figure 113.—Male stage V, P5; scale D.

cate. In lateral view with flat, gentle forward slope. Th4 and Th5 separate; Th5 lateral corners slightly prolonged; Th1-Th4 without lateral spinules. Prosome length about 3⅔ times urosome. Genital segment as long as wide, protruding ventrally one-third depth of rest of urosome. Caudal rami as long as wide, left ramus slightly larger than right. Left terminal second from inner seta thickest, length ca. 2.1 mm; left and right terminal second from outer seta relatively thick to near tip; right inner seta larger than left, with long plumes.

A1 exceeding caudal rami by about 4 segments; terminal segments (Fig. 155) elongate. Apparent deviation: I-1s; remainder as Table 4.

A2 Re1 with 1 seta.

Mn palp with inner row of long setules on distal anterior surface of B2 and on surface of Ri1. Blade (Fig. 100) with 5 outer subequal teeth, ventral tooth 1-pointed, others at least 2-pointed; 3 narrow teeth, followed by outer seta, dorsally; proximal anterior surface with clusters of stiff hairs.

Mx1 gnathobase with 4 proximal setae on posterior surface, without seta on distal anterior surface.

Mx2 with setule-covered proximal hump and outer seta; posterior surface of lobe-5 base without spines.

Mxp (Fig. 105) B1 with 3 transverse spine-combs on distal outer surface; proximal transverse row and distal oblique row of setules on anterior surface; inner distal hump with row of denticles. B2 with strong transverse spine-comb about one-third length on outer surface; inner longitudinal row of stiff hairs. Ri1 with distal row of stiff hairs; Ri3 with only 2 setae; Ri5 with inner spinules. Ri4-5 outer setae nude, bladelike, tapering toward each end.

P1 (Fig. 101) B1-2 anterior surface with few rows of setules; inner margin with hairs. Re1-2 anterior surface with outer distal row of spinules; Re3 surface nude. Re1-2 outer spines barely reaching bases of following spines. Ri distal anterior surface with few short setules.

P2 (Fig. 102) B1 outer surface with few spinules and setules, inner margin with hairs; B2 nude. P3 (Fig. 103) B1 outer surface with few spines, spinules, and setules, inner margin with hairs; B2 nude. P4 (Fig. 104) B1 proximal inner posterior surface with row of long and short setules; inner margin without hairs; B2 nude.

P3-P4 Re2 posterior surface with proximal row of large, fairly wide spines and distal row of smaller spines.

P2 Re3 rarely with few small proximal spines, usually only with 2 distal rows of spines. P3-P4 Re3 with 3 evenly spaced rows of spines, spine-size decreasing distally.

Re terminal seta with following number of primary teeth: P2 (37-44); P3 (38-49); P4 (40-44).

Male.—Length 1.4-1.76 mm (Figs. 106, 107). Prosome anterior irregular in dorsal view, posterior somewhat rectangular; in lateral view with gentle forward slope. Ce and Th1 partly fused. Prosome length 2½ times urosome. Caudal rami about as long as wide, symmetrical. Caudal setae symmetrical.

A1 reaching distal edge of urosome segment 1; segment 1 without cluster of spinules on anterodorsal surface. IV-2s, 2e; VIII-2s, 2e; XV-2s, 1e; XIX-2s, 1e; right XX-0; left XX-1e; remainder as Table 4.

A2 Re1 with reduced seta.

Mn blade and Mx1 gnathobase reduced. Mx2 with fragile outer seta; setae of reduced length, terminal setae thicker than on female; lobe surfaces nude.

Mxp (Fig. 108) B1 setae of reduced length, surfaces nude. B2 with longitudinal row of long stiff hairs. Longest setae of Ri2-5 nude, not inflated; Ri4-5 outer setae reduced, nude; no spinules on inner Ri5. Ri3 with 3 setae.

P1 (Fig. 109) B1-2 with fewer outer setules on anterior surface than on female; Re1-3 and Ri surface nude. Re1 outer spine reaching about one-half length of Re2. Re2 outer spine stronger than on female.

P2 (Fig. 110) Re2 with cluster, not row, of ca. 9 spines on posterior surface. Re2-3 outer spines longer than on female, reaching to base of following spines. Spiniform terminal edge of Re3 longer than on female.

P3 (Fig. 111) Re2 posterior surface proximal spines wider than on female; distal spines in cluster. Re3 similar to P2 Re3.

P4 B1-2 nude. Re1 and Ri as on female. Re2-3 missing on specimens examined.

Re terminal seta with finer serrations than on female: P2 (63-70); P3 (ca. 64).

P5 (Fig. 112) biramus, left-handed; reaching to end of urosome segment 2. Left B1 reaching middle of right B2; left B2 reaching one-third length of right Re1. Left and right legs about equal. Right Re, including long terminal blade, slightly longer than left; right Ri much longer than left. Order of length, longest to shortest, of Re segments: left and right 1 = 2, 3. Left Ri reaching two-thirds length of left Re2. Right Ri reaching two-thirds length of longest right Re terminal blade. Each Re1 with short seta on outer distal edge. Inner edge of left Re2-3 with long hairs. Each Re with 1 small and 1 moderate bladelike terminal setae.

Male stage V.—Length 1.48-1.53 mm. P5 (Fig. 113) biramus, symmetrical. Re imperfectly 2-segmented; outer distal edge of Re1 with short, flat seta; 2 short, unequally wide, terminal setae. Ri with trace of segmentation; terminal seta reaches nearly to end of Re.

Remarks

In addition to the female of *S. elongatus*, Brodsky (1950) described two distinct males under the name *S. elongatus*. The "typical" male is *S. polaris* (see below); the "variant" male is *S. elongatus*.

Distribution

Spinocalanus elongatus is the only species of the present study that is known only from the Arctic Ocean. Bogorov (1946a) reported two female Arctic *S. abyssalis*, which he distinguished, by their size, from *S. longicornis*; this is considered a record of *S. elongatus* in the present study, since no other likely species has been found in the Central Arctic. The records of *S. elongatus* are summarized below:

Arctic Ocean
Central: Brodsky (1950, 1957), 25-3,000 m.
Eurasian Basin: Bogorov (1946a), 10-750 m.
Canadian Basin: Brodsky and Nikitin (1955), 100-3,826 m. —Dunbar and Harding (1968), 175-2,000 m. —Vidal (1971). —Present study, 300-2,500 m.

26. *Spinocalanus polaris* Brodsky, 1950

(Figures 114-129, 156)

Spinocalanus polaris Brodsky, 1950, p. 133, fig. 53. —Grice and Hulsemann, 1965, p. 229-230, fig. 7g. —Park, 1970, p. 493, fig. 71-77. —Vidal, 1971, p. 18, fig. 36-37, 39.
Spinocalanus elongatus Brodsky, 1950 (part), p. 132-133, fig. 52; "male" but not "male variant."

TYPE SPECIMEN: Unknown.
TYPE LOCALITY: Central Arctic Ocean, 800-2,500 m.
MATERIAL STUDIED: 1 male (1.60 mm), sample A17 (Table 1); 2 males (1.60, 1.64 mm), sample A26; 3 females (1.28, 1.32, 1.40 mm) and 1 male (1.68 mm), sample A31; 12 females (1.36-1.56 mm, mean = 1.47 mm) and 1 male (1.56 mm), sample A48; 7 males (1.44-1.68 mm, mean = 1.55 mm), sample A50; 6 females (1.30-1.42 mm, mean = 1.36 mm) and 7 males (1.45-1.55 mm, mean = 1.49 mm), sample A51.

Description

P1 Ri with 1 inner seta; P2 Ri2 with no outer seta; P3-P4 Ri3 with 1 outer seta.

Female.—Length (1.02?-) 1.17-1.60 mm (Figs. 114, 115). Prosome in dorsal view fairly robust ovoid; head abruptly narrow, rounded. In lateral view with fairly abrupt forward slope. Th4 and Th5 separate; Th5 lateral corners prolonged, reaching midgenital segment; Th1-Th4 without lateral spinules. Prosome length about 3⅔ times urosome. Genital segment slightly longer than wide, protruding ventrally one-half depth of rest of urosome. Caudal rami length 1⅓ times width, symmetrical. Caudal setae broken in all specimens; bases symmetrical.

A1 exceeding caudal rami by about 1½ segments; terminal segments (Fig. 156) of moderate length and width. Armature as Table 4.

A2 Re1 with 1 seta.

Mn B2 surface without setules; Re1 outer distal surface with row of setules. Blade (Fig. 121) with 4 subequal outer teeth, ventral tooth 1-pointed, others 3-pointed; 4 shorter 2-pointed teeth, followed by dorsal seta; midanterior surface with transverse row of long spinules.

Mx1 gnathobase (Fig. 122) with 4 proximal setae on posterior surface, without seta on distal anterior surface. Posterior surface with proximal cluster of strong denticles, central cluster of smaller denticles, and outer cluster of spinules.

Mx2 with small setule- and hair-covered proximal hump; no outer seta seen (Park, 1970, fig. 74, shows outer seta). Distal hook on lobe-1 (Fig. 116) prominent. Posterior surface of lobe-5 base without spines.

Mxp (Fig. 123) B1-2 without transverse spine-combs. B1 anterior surface with 1 proximal and 3 distal transverse rows of long setules; outer longitudinal row of setules and inner longitudinal row of spines about midlength; longitudinal row of short, stiff hairs near inner distal edge. B2 with longitudinal row of short, stiff hairs. Ri1 inner distal edge with row of stiff hairs. Ri4-5 outer setae unmodified, thin, relatively short, probably lightly plumose; Ri5 inner edge without spinules.

P1 (Fig. 117) B1-2 anterior surface with few rows of setules; B1 inner margin with setules; B2 inner margin with setules and hairs. Re1 anterior surface with outer distal row of spines; Re2 *posterior* surface with distal row of spines; Re3 surface nude. Re1-2 outer spines reaching base of following spine. Ri inner midlength surface with spinules. Re terminal seta relatively coarsely serrate.

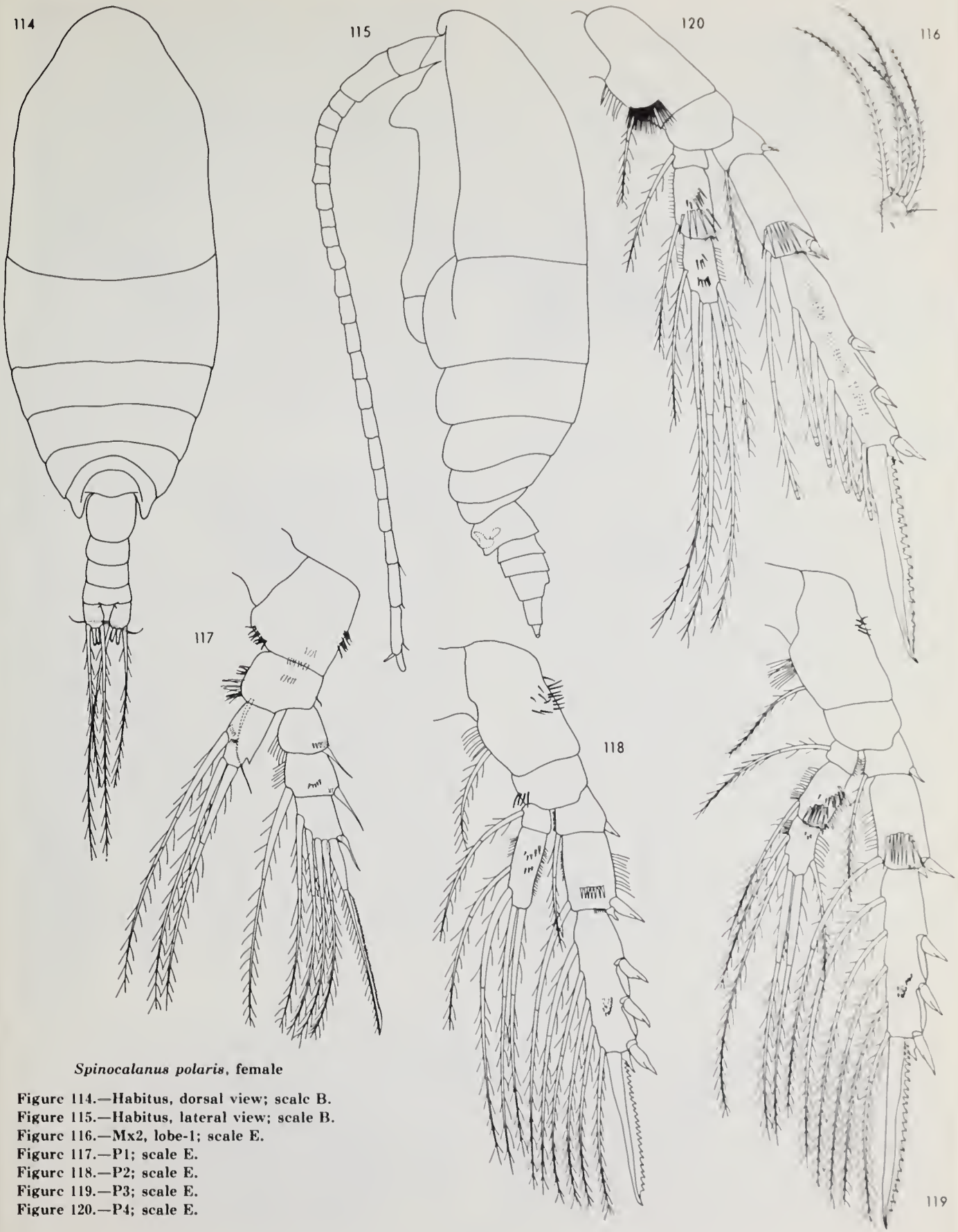
P2 (Fig. 118) B1 outer surface with setules, inner margin with hairs. B2 inner posterior surface with few setules. Re2 distal posterior surface with straight row of spines; Re3 distal anterior and posterior surface with group of small spines.

P3 (Fig. 119) B1 proximal outer surface with few setules; inner margin with hairs. Re2 posterior surface with 1 distal row of long spines; Re3 distal anterior and posterior surface with group of small spines. Ri3 proximal posterior surface with few small spines.

P4 (Fig. 120) B1 inner margin with hairs; posterior surface with transverse row of long *spinules*. Re2 posterior surface with 1 distal row of long spines; Re3 posterior surface with 3 evenly spaced longitudinal groups of denticles.

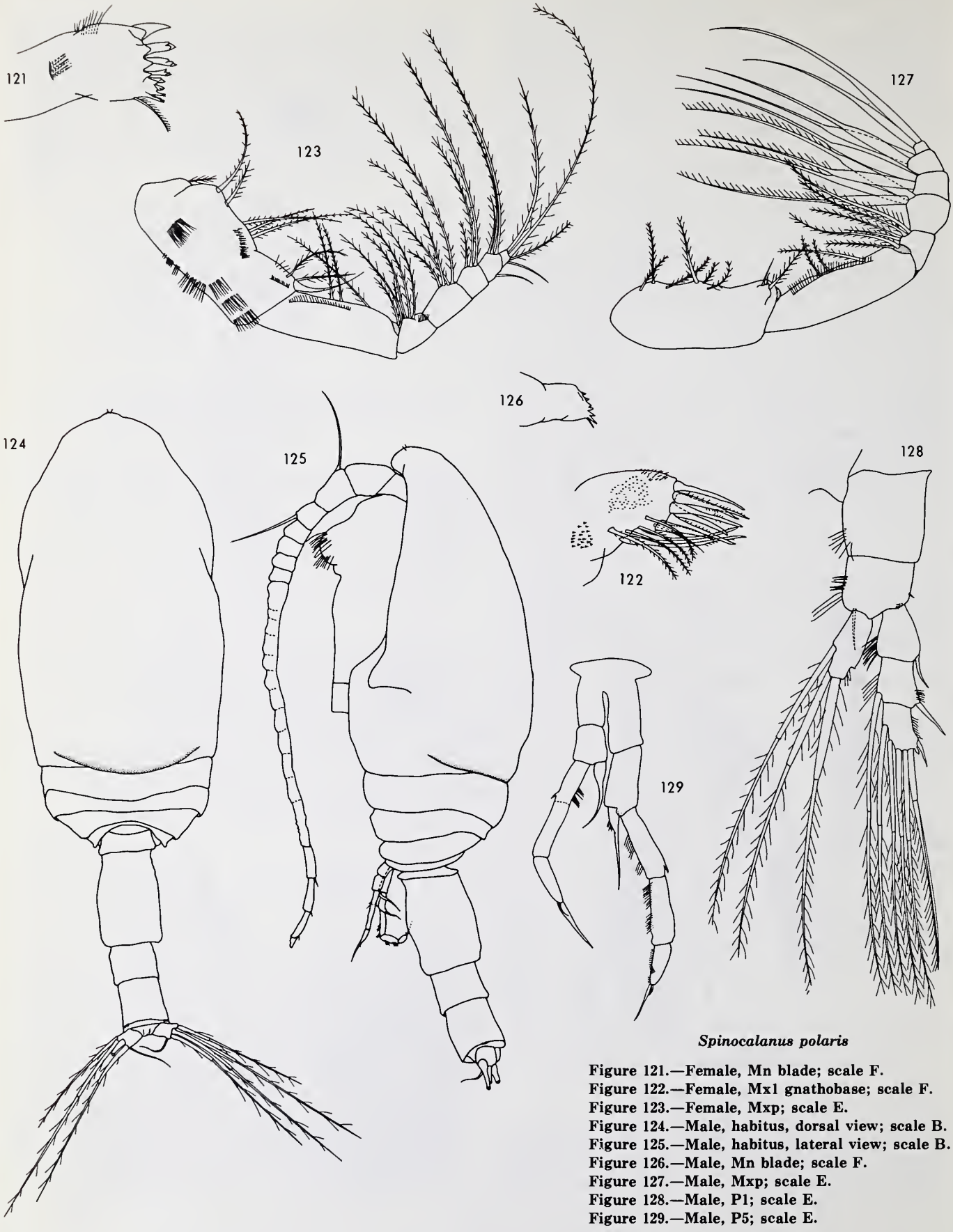
Re terminal seta with following number of primary teeth: P2 (23-29); P3 (ca. 20); P4 (ca. 20; secondary teeth relatively large, irregular.)

Male.—Length 1.44-1.68 mm (Figs. 124, 125). Prosome anterior somewhat rounded in dorsal view, posterior somewhat rectangular; in lateral view with gentle forward slope. Ce and Th1 partly fused.



Spinocalanus polaris, female

Figure 114.—Habitus, dorsal view; scale B.
Figure 115.—Habitus, lateral view; scale B.
Figure 116.—Mx2, lobe-1; scale E.
Figure 117.—P1; scale E.
Figure 118.—P2; scale E.
Figure 119.—P3; scale E.
Figure 120.—P4; scale E.



Spinocalanus polaris

Figure 121.—Female, Mn blade; scale F.
Figure 122.—Female, Mx1 gnathobase; scale F.
Figure 123.—Female, Mxp; scale E.
Figure 124.—Male, habitus, dorsal view; scale B.
Figure 125.—Male, habitus, lateral view; scale B.
Figure 126.—Male, Mn blade; scale F.
Figure 127.—Male, Mxp; scale E.
Figure 128.—Male, P1; scale E.
Figure 129.—Male, P5; scale E.

Prosome length 2 times urosome. Caudal rami slightly longer than wide, symmetrical. Caudal setae incomplete on specimens examined, bases symmetrical.

A1 reaching middle of urosome segment 2; *left* segment 20 merging with segment 21, typical of *right-handed* males; segment 25 reduced. IV-2s, 1e; VIII-2s, 2e; XV-1s, 1e; XIX-1s, 1e; right XX-1s; left XX-0; remainder as Table 4.

A2 Re1 with 1 seta.

Mn blade (Fig. 126) reduced; dorsal tooth relatively long.

Mx2 long terminal setae much thicker than on female.

Mxp (Fig. 127) B1 setae of reduced length, surface nude. B2 with longitudinal row of stiff hairs. Ri2-5 inner setae inflated about one-third length; Ri2 setae and Ri3 proximal seta distally plumose; other inflated setae nude. Ri2 apparently with only 3 setae, Ri3-5 apparently with only 2 setae. Ri4-5 outer setae and Ri5 terminal seta apparently absent. No spinules on inner Ri5.

P1 (Fig. 128) B1 with only few hairs on inner margin. B2 anterior surface with outer distal row of spinules; inner edge with setules and hairs. Re and Ri surface nude. Re3 terminal seta not coarsely serrate.

P2 as on female except Re2 surface spines longer, and Re3 terminal seta with 66-69 primary teeth.

P3 as on female except Re3 outer spines longer, and terminal seta with ca. 73 primary teeth.

P4 B1 nude (one specimen with rudimentary right inner seta). Re2-3 missing on specimens examined, remainder as on female.

P5 (Fig. 129) biramus, *right-handed*; reaching end of urosome segment 2. Right B1 reaching three-fourths length of left B2; right B2 reaching left Re2. Right leg longer than left; right and left Re, including terminal blade, about equal length; right and left Ri about equal length. Order of length, longest to shortest, of Re segments: left 2, 3, 1; right 1 = 2, 3. Left Ri reaching middle of left Re2. Right Ri reaching one-third length of right Re2. Each Re1 with short, flat seta on distal outer edge. Left Re1-2 more or less fused; inner edge of Re1 with few setules. Inner edge of right Re and Ri with hairs. Each Re with 1 small and 1 moderate bladelike terminal setae.

Remarks

Brodsky (1950) based his description of *S. polaris* solely on females, and considered *S. polaris* male as one of two types of male *S. elongatus*. Brodsky and Nikitin (1955) reported male *S. polaris*, so that they may have recognized this error.

Park's (1970) lengths of females (1.02-1.06 mm) have been questioned in the above description; these should be verified, in view of the differences between some of his published lengths and present measurements of the same specimens.

Distribution

Records of *S. polaris* are summarized below:

Arctic Ocean
- Central: Brodsky (1950, 1957), 200-3,000 m.
- Canadian Basin: Brodsky and Nikitin (1955), 0-3,826 m. —Dunbar and Harding (1968), 900-3,000 m. —Vidal (1971). —Present study, 1,500-3,000 m.

Atlantic Ocean
- East: Grice and Hulsemann (1965), 1,500-5,000 m.
- Caribbean Sea: Park (1970), 980-2,800 m.

Brodsky (1957) recorded *S. polaris*, with some doubt, from the north and northwest Pacific. Some *Mimocalanus* species look like *S. polaris*, and if specimens are damaged, they could easily be confused.

27. *Spinocalanus brevicaudatus* Brodsky, 1950

(Figures 130-136, 157)

Spinocalanus longicornis. —Sars, 1901, p. 22-23, pl. 12. Not *S. longicornis* Sars, 1900.

Spinocalanus abyssalis. —Sars, 1903, p. 157-158, suppl. pl. 3, fig. 2. —van Breemen, 1908 (part), p. 28-29, fig. 27a, c (only). —With, 1915, p. 69-71, fig. 15; pl. 1, fig. 10a-b. —Rose, 1933, p. 84-85, fig. 42. —Tanaka, 1937 (part), p. 253-254, fig. 4d-e; male only. —Davis, 1949, p. 21-22, fig. 23-24. —Farran and Vervoort, 1951a (part), p. 2-3, fig. 1a-d, i (only). —Grice and Hulsemann, 1965, p. 229, fig. 7a. Not *S. abyssalis* Giesbrecht, 1888.

Spinocalanus major Esterly, 1906, p. 55.

Spinocalanus pseudospinipes Brodsky, 1950, p. 127-128, fig. 46.

Spinocalanus sp.? Brodsky, 1950 (part), p. 130-131, fig. 50; male only.

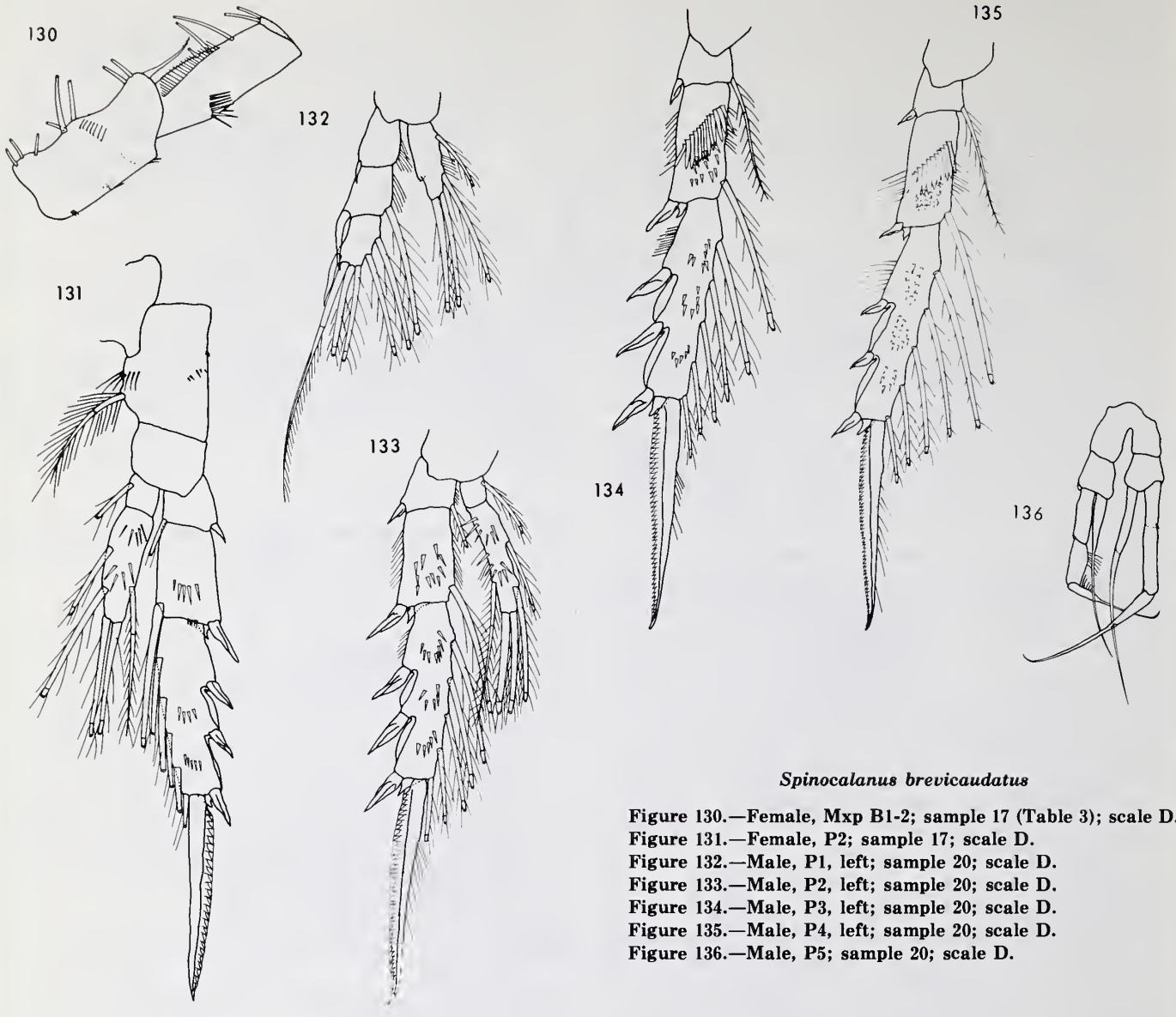
Spinocalanus brevicaudatus Brodsky, 1950, p. 134-136, fig. 55. —Semenova, 1962, p. 1571-1574, fig. 1-4.

Spinocalanus similis var. *profundalis* Brodsky, 1955 (part), p. 185-187, fig. 1a-c; female only.

TYPE SPECIMEN: Lectotype, female (1.60 mm) OSLO F4923a.

TYPE LOCALITY: Northeast Atlantic (Osterfjord), 400-600 m.

MATERIAL STUDIED: 3 females (1.55, 1.57, 1.60 mm), sample 3 (Table 3); paralectotype, female (1.60 mm, after Sars, 1901), on slide, sample 16; paralectotype, female, on slide, sample 17; lectotype, female (1.60 mm) and 1 male stage V (1.40 mm), sample 18; 2 paralectotypes, females (1.60 mm), sample 19; paralectotype, male (1.60 mm, after Sars, 1903), on slides, sample 20; 1 female (1.42 mm), sample 21; 1



Spinocalanus brevicaudatus

Figure 130.—Female, Mxp B1-2; sample 17 (Table 3); scale D.
Figure 131.—Female, P2; sample 17; scale D.
Figure 132.—Male, P1, left; sample 20; scale D.
Figure 133.—Male, P2, left; sample 20; scale D.
Figure 134.—Male, P3, left; sample 20; scale D.
Figure 135.—Male, P4, left; sample 20; scale D.
Figure 136.—Male, P5; sample 20; scale D.

female (1.45 mm), sample 25; 1 female (1.47 mm), sample 26; 1 female (1.68 mm), sample 30; 1 female (1.95 mm) and 1 male (1.90 mm), sample 31; 1 female (1.85 mm), sample 33.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.40-2.4 mm. Prosome in dorsal view ovoid, head slightly truncate. In lateral view with fairly abrupt forward slope. Th4 and Th5 separate; Th5 lateral corners rounded, not prolonged; Th1-Th4 without lateral spinules. Prosome/urosome ratio variable; prosome 3-4 times urosome. Genital segment as long as wide, protruding ventrally one-half depth of rest of urosome. Caudal rami as long as wide, symmetrical. Caudal setae symmetrical.

A1 exceeding caudal rami by about 2 segments; terminal segments (Fig. 157) of moderate length and width. Most segments damaged on material studied.

A2 Re1 with 2 setae.

Mx2 posterior surface of lobe-5 base apparently without spines.

Mxp (Fig. 130) with typical number of setae; B1 surface with few rows of setules. B2 with transverse spine-comb about one-third length on outer surface; inner longitudinal row of stiff hairs. Ri4-5 outer setae nude, bladelike, tapering toward each end; not as shown by Sars (1901). Ri5 with inner spinules.

P1 similar to that in *S. elongatus*, Re3 posterior surface without spines. Sars' (1901) figure lacks 1 inner seta on Re3.

P2 (Fig. 131) B1 outer surface with few spinules; inner posterior surface with setules. P3 B1 outer surface with few setules, spinules, and weak spines; inner

margin with hairs. P4 B1 proximal inner posterior surface with row of long and short setules; inner margin without hairs.

P4 B2 posterior surface nude or with several thin setules.

P3-P4 Re2 posterior surface with proximal row of strong, fairly wide spines and distal row of smaller spines. Ri2-3 surface spines shorter than on *S. elongatus*.

P2 Re3 with 2 distal rows of spines. P3 Re3 with 3 evenly spaced rows of spines as on *S. elongatus*. P4 Re3 posterior surface with 3 groups of spines, smaller and fewer than on *S. elongatus*. Outer spines of P2-P4 Re2-3 longer than on *S. elongatus*.

Re terminal seta with following number of primary teeth: P2 (ca. 25); P3 (21-25); P4 (25-27).

Male.—Length (1.3?-) 1.5-1.90 mm. Prosome anterior irregular in dorsal view, posterior somewhat rounded; in lateral view with fairly abrupt forward slope. Prosome length 2⅓ times urosome. Caudal rami about as long as wide, symmetrical. Caudal setae symmetrical.

A1 reaching middle of urosome segment 2; segment 1 with cluster of short spinules on anterodorsal surface. IV-2s, 2e; VIII-2s, 2e; XV-1s, 1e; XIX-1s?, 1e; right XX-damaged; left XX-1e; remainder as Table 4.

Mxp Ri4-5 outer setae reduced; Ri5 inner edge without spinules.

P1 (Fig. 132) similar to that of *S. elongatus* male except Re1 outer spine shorter, Re2 outer spine larger.

P2 (Fig. 133) as on female, except no anterior spinules on Re2, other surface spines slightly stronger, Re2 spines in cluster, Re3 with 3 rows of spines, and terminal seta with ca. 45 teeth.

P3 (Fig. 134) as on female except no anterior spinules on Re2, Re2 with distal cluster of spines, and Re3 terminal seta with ca. 48 teeth.

P4 (Fig. 135) as on female except B1 without inner seta and without inner transverse row of setules, Re2 with distal cluster of spines, Re3 surface spines stronger, and Re3 terminal seta with ca. 54 teeth.

P5 (Fig. 136) biramus, left-handed. Left B1 reaching one-third length of right B2; left B2 reaching middle of right Re1. Right leg, including terminal blade, longer than left. Right Re longer than left; right Ri longer than left. Order of length, longest to shortest, of Re segments: left 1, 2, 3; right 2, 1 = 3. Left Ri reaching two-thirds length of longest left Re terminal blade. Right Ri reaching about to end of longest right Re terminal blade. Probably each Re1 with short seta on outer distal edge. Right Re1-2 more or less fused. Inner edge of left Re2-3 with long hairs. Each Re probably with 1 small and 1 moderate bladelike terminal setae.

Remarks

Sars (1901) described a Norwegian *Spinocalanus* species as *S. longicornis*, later (1903) adding the male and changing the name to *S. abyssalis*. Sars (1901) neglected to describe the outer seta of P2 Ri2 of his Norwegian specimens; a remounting of his preparation clearly showed this seta (Fig. 128). Sars also failed initially to describe the surface spination of P2-P4 Re on his female specimens. These omissions, and the incomplete descriptions of *S. abyssalis* Giesbrecht, masked the distinctness of Sars' specimens. Most subsequent workers seemed to follow the authority of Sars, who incorrectly equated the Norwegian species (common in the North Atlantic) with both *S. abyssalis* Giesbrecht and *S. longicornis* Sars, 1900.

Farran (1926) recognized two size groups in the Northeast Atlantic, the larger representing Sars' Norwegian species. Unfortunately Farran retained the name *abyssalis* for this group, renaming the smaller forms *abyssalis* var. *pygmaeus* (see *S. longicornis* Sars, 1900).

Sars' (1903) figure of male P5 was poorly printed, the end of left Ri not shown well; therefore, later copies of this figure (Rose, 1933; Brodsky, 1950; Farran and Vervoort, 1951a) failed to show the full length of left Ri. This specimen's appendage has been redrawn in the present study (Fig. 133).

Van Breemen (1908), Rose (1933), and Farran and Vervoort (1951a) copied some of Sars' figures, although they included figures or descriptions of *S. abyssalis* Giesbrecht and *S. longicornis* as well.

With (1915) included a brief description of male stage V.

Tanaka (1937) apparently combined one female *S. horridus* (see above) and one male *S. brevicaudatus* as *S. abyssalis*. Brodsky (1950) recognized that neither represented *S. abyssalis* Giesbrecht, and considered Tanaka's specimens "*Spinocalanus* sp.?"

Davis (1949) correctly illustrated *S. brevicaudatus* P2 Ri2 with 1 outer seta, but failed to note its distinctness from *S. abyssalis*.

Grice and Hulsemann (1965) gave a lateral view of the female *S. brevicaudatus*; their unpublished station list (1966) indicated a size of 1.4-2.0 mm (female) and 1.3 mm (male). This small male might be *S. longicornis*, and the length is questioned in the size range of males given above.

Esterly (1906) very briefly, and without illustrations, described a single female as a new species, *S. major*. There is nothing in Esterly's description that sets *S. major* apart from *S. abyssalis*, except *S. major*'s larger size. A. Fleminger examined the Esterly Collection and located a single slide which was labeled "*Spinocalanus*." This slide, now deposited in the U.S. National Museum (USNM 143692), contained only A2, Mx1, and Mxp, which appeared consistent with those appendages of *S. brevicaudatus*. However, the lack of P1 and P2 makes this identification uncertain. *Spinocalanus brevicaudatus* is known from the area in which Esterly found *S. major*; his brief description is consistent with that of *S. brevicaudatus*, which is considered in the present

study to be conspecific. Since *S. major* was not well described, since the specimen from the Esterly Collection is probably but not certainly *S. major*, and since *S. major* has remained unused in the primary zoological literature for more than 50 yr, "*S. major*" should probably be suppressed.

Brodsky's (1950) description of *S. pseudospinipes* is consistent with that of *S. brevicaudatus*, with the exception that male P5 (left?) Ri, perhaps broken, is somewhat shorter (Brodsky, fig. 46). The description of *S. pseudospinipes* precedes by pages that of *S. brevicaudatus*, but the latter name is well established by recent redescriptions and records, and *S. pseudospinipes*, by comparison, has been little used and not redescribed.

Brodsky (1950) was the first to point out that Sars' Norwegian specimens were distinct from both *S. abyssalis* and *S. longicornis*, and renamed them *S. brevicaudatus*. Brodsky did not have specimens, but referred only to Sars' (1901, 1903) descriptions. Semenova (1962) redescribed *S. brevicaudatus* from fresh specimens; Ri of P1-P2 were not described, but the species was defined essentially by size, body shape, P3-P4 Re2 posterior surface spines, and male P5.

Brodsky (1955) briefly described *S. similis* var. *profundalis*; the description of the female is consistent with that of *S. brevicaudatus*.

Distribution

Most of the records summarized below are of *S. abyssalis* that probably represent *S. brevicaudatus*. In some cases the specimens have been reexamined; in other cases, a size, description, or other reference was reported which suggested *S. brevicaudatus*. Records which include specimens smaller than 1.40 mm are probably also of *S. abyssalis* Giesbrecht and/or *S. longicornis* Sars. Tanaka's (1937, 1953, 1956) record also includes *S. horridus* female.

Brodsky (1950) considered Jespersen's (1934) record of *S. abyssalis* as *S. brevicaudatus*. In this and subsequent publications, Jespersen (1939a, b; 1940) did not report specimen size, but indicated that they were equivalent to *S. abyssalis* Giesbrecht and *S. longicornis* Sars, as well as *S. brevicaudatus* (as its synonyms). Therefore, Jespersen's records are considered as a probable mixture of species. Likewise, Störmer's (1929) and Østvedt's (1955) records of *S. abyssalis* from nearby areas cannot be strictly interpreted. However, since the known distribution of *S. brevicaudatus* includes most of the areas sampled by Störmer, Jespersen, and Østvedt, their records are in the following summary. Some of this material, especially that of Jespersen (1934) from Baffin Bay, should be reexamined.

Vervoort's (1951) record is not included in the following summary (see *S. terranovae*).

Three records of *S. longicornis* are considered to be of *S. brevicaudatus*: Gran (1902), identified by G. O. Sars, perhaps the specimen in sample 21 (Table 3); Hoek (1906), identified by C. Wesenberg-Lund and G. O. Sars; and Ostenfeld (1916), identified by G. P. Farran.

The records of *Spinocalanus* sp. by Figueira (1971) and Roe (1972a, b) are considered to be of *S. brevicaudatus*.

Pesta (1927) cites Sars' Norwegian record of *S. brevicaudatus* as both *S. abyssalis* and *S. longicornis*.

Grainger (1965) listed *S. brevicaudatus* from the Central Arctic, but this was only a reference to Bogorov's (1946a) record of *S. abyssalis* (E. H. Grainger, pers. commun.). Bogorov's specimens are considered in the present study to be *S. elongatus*, since *S. brevicaudatus* has not been reported from the Central Arctic.

Park (1970) reported *S. brevicaudatus* from the Caribbean; four of his five specimens were examined in the present study; two are considered *S. abyssalis* and two *S. aspinosus*.

Grice (1971) listed *S. brevicaudatus* from the Mediterranean Sea, but this was a misinterpretation of Rose's (1933) summary (G. Grice, pers. commun.).

Pacific Ocean
- North: Brodsky (1950), 1,000-4,000 m.
- Northeast: Esterly (1906), 360 m. —Davis (1949), 0-2,300 m. —Fulton (1968), below 200 m. —von Vaupel-Klein (1970), 0-1,200 m. —Figueira (1971). —Present study, 0-400 m.
- Central: Present study, 0-1,000 m.
- Northwest: Tanaka (1937, 1953, 1956), below 200 m. —Brodsky (1952a, 1955, 1957), 0-8,500 m. —Furuhashi (1966), 298-775 m.
- Indo-Pacific: Vervoort (1946), 355-2,500 m.

Indian Ocean
- West: Grice and Hulsemann (1967), 750-3,000 m.

Atlantic Ocean
- North: Störmer (1929), 50-1,500 m. —Jespersen (1934; 1939a, b; 1940), 0-1,500 m. —Østvedt (1955), 100-2,000 m. —Semenova (1962), below 300 m.
- Northeast: Sars (1901, 1903), 400-600 m. —Gran (1902), 200-1,000 m. —Hoek (1906). —Farran (1908, 1920, 1926), 180-3,600 m. —Nordgaard (1912), 200-600 m. —Ostenfeld (1916). —Lysholm and Nordgaard (1921), 600-1,000 m. —Sars (1924, 1925), 0-4,000 m. —Runnström (1932), 100-400 m. —Grice and Hulsemann (1965), 180-4,000 m. —Present study, 1,260 m.
- East: Roe (1972a, b), 350-960 m.
- Southeast: Unteruberbacher (1964), 0-300 m.
- Central: Wheeler (1970), 2,000-4,000 m.
- Northwest: With (1915), 0-360 m. —Semenova (1962), below 300 m. —Grice (1963), 620-1,200 m. —Wheeler (1970), 2,000-4,000 m.
- Caribbean Sea: Park (1970), 1,004-1,850 m.

Some of Farran's specimens of *S. abyssalis* (=*S. brevicaudatus*) are in the collection of the National Museum of Ireland, Dublin (O'Riordan, 1969).

(28. *Spinocalanus similis* var. *profundalis* Brodsky, 1955)

Female, see *Spinocalanus brevicaudatus* Brodsky, 1950. Male, see *S. similis* Brodsky, 1950.

(29. *Spinocalanus longipes* Tanaka, 1956) (*S. longipes* Tanaka, 1953, nomen nudum)

See *Spinocalanus angusticeps* Sars, 1920.

(30. *Spinocalanus*? sp. Johnson, 1963a)

See *Spinocalanus antarcticus* Wolfenden, 1906.

31. *Spinocalanus abruptus* Grice and Hulsemann, 1965

Spinocalanus abruptus Grice and Hulsemann, 1965, p. 227-229, fig. 6m-p.

TYPE SPECIMEN: Holotype, female, BM 1965.4.20.34.
TYPE LOCALITY: Northeast Atlantic, 1,000-2,800 m.
MATERIAL STUDIED: Paratypes, 2 females (1.30-1.32 mm), sample 49 (Table 3).

Description

P1 Ri with 2 inner setae. P2 Ri2 with 1 outer seta (?).

Female.—Length 1.29-1.47 mm. Specimens examined in present study damaged. Prosome in dorsal view ovoid. Th4 and Th5 separate. Th5 lateral corners prolonged, variable, more prolonged than shown by Grice and Hulsemann (1965). Th1-Th4 without lateral spinules. Prosome length 4-4½ times urosome. Caudal rami symmetrical.

Mx2 with small spinule- and setule-covered hump on proximal outer edge; no outer seta seen; posterior surface of lobe-5 base without spines.

Mxp B1-2 without transverse spine-comb. B1 with few transverse rows of short setules (Grice and Hulsemann, 1965, fig. 6n).

P1 as shown by Grice and Hulsemann except outer setules on B1 surface, and B2 outer edge with short seta, anterior surface with outer distal row of spinules, inner surface with setules.

P2-P4 rami missing on specimens examined. P2 perhaps with 1 outer seta on Ri2, although not clear on illustration by Grice and Hulsemann (1965, fig. 6p); B1 with inner seta, not shown by Grice and Hulsemann.

Male.—Unknown.

Remarks

Spinocalanus abruptus is the only *Spinocalanus* species in the group with 2 inner setae on P1 Ri and 1 outer seta on P2 Ri2 that also has prolonged Th5 or is without transverse spine-comb on Mxp B2.

Distribution

Indian Ocean
  West: Grice and Hulsemann (1967), 1,000-3,000 m.
Atlantic Ocean
  Northeast: Grice and Hulsemann (1965), 1,000-2,800 m.

(32. *Spinocalanus ovalis* Grice and Hulsemann, 1965)

See *Mimocalanus ovalis* (Grice and Hulsemann, 1965).

(33. *Spinocalanus ventriosus* Grice and Hulsemann, 1967)

See *Mimocalanus ovalis* (Grice and Hulsemann, 1965).

(34. *Spinocalanus* sp. Grice and Hulsemann, 1967)

Spinocalanus sp. Grice and Hulsemann, 1967, p. 22, fig. 35.

Remarks

Grice and Hulsemann (1967) briefly described a single male from the Indian Ocean as *Spinocalanus* species. This specimen was examined in the present study (sample 52, Table 3). P1 Re3 with a total of 4 setae, and therefore the specimen is *not* a *Spinocalanus* species. P2-P4 rami missing; P2 B2 distal edge spiniform, somewhat similar to *Clausocalanus* species. A1 segments beyond 10 are much longer than in *Spinocalanus* species.

(35. *Spinocalanus parabyssalis* Park, 1970)

Female, see *Spinocalanus longicornis* Sars, 1900. Male, see *S. abyssalis* Giesbrecht, 1888.

(36. *Spinocalanus pteronus* Park, 1970)

See *Spinocalanus usitatus* Park, 1970.

37. *Spinocalanus usitatus* Park, 1970

(Figures 137-140)

Spinocalanus pteronus Park, 1970, p. 487, fig. 43-50.
Spinocalanus usitatus Park, 1970, p. 487-489, fig. 51-54.

TYPE SPECIMEN: Holotype, female (1.62 mm), USNM 123785.
TYPE LOCALITY: Caribbean Sea, 487-950 m.
MATERIAL STUDIED: 1 female (1.88 mm), sample 31 (Table 3); 1 female (1.65 mm), sample 32; 1 female (1.68 mm), sample 34; holotype, female (1.62 mm), sample 55; 2 paratypes, females (1.38, 1.52 mm), sample 56. Also the following type specimens of *Spinocalanus pteronus*: holotype, female (1.93 mm) and 1 paratype, female (1.80 mm), sample 54; 5 paratypes, females (1.70-1.82 mm, mean = 1.76 mm), sample 59.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.38-1.93 mm (Figs. 137, 138). Body similar to *S. spinosus*; prosome in dorsal view somewhat robust ovoid, head slightly truncate; in lateral view with abrupt forward slope. Th4 and Th5 separate; Th5 lateral corners rounded, not prolonged. Th1-Th4 with lateral spinules, number decreasing posteriorly, approximately even right and left. Prosome length 2½-3 times urosome.

A1 incomplete on specimens examined.

A2 Re1 with 2 setae.

Mx2 (Fig. 139) as on *S. spinosus* except posterior surface of lobe-5 base with spines.

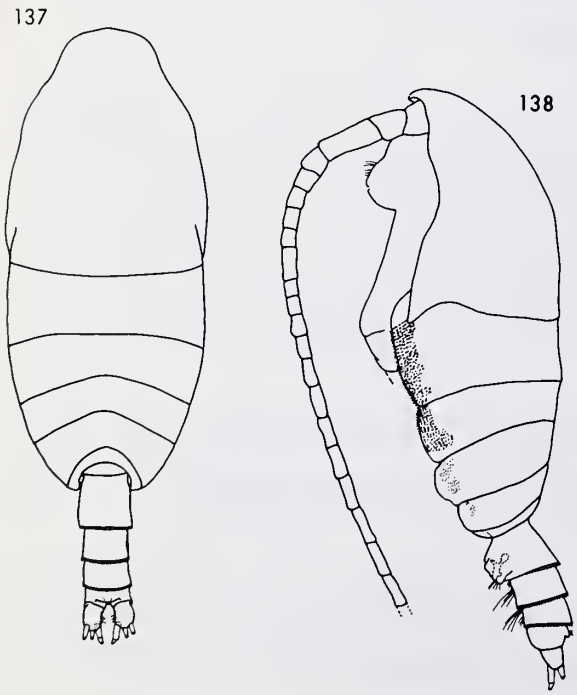
Mxp (Fig. 140) as on *S. spinosus* except B1 with transverse spine-comb on outer edge; oblique row of setules on midanterior surface; distal hump with oblique row of spinules on anterior surface; posterior surface near distal outer edge with transverse row of setules. B2 with strong transverse spine-comb; longitudinal row of spinules. Remaining segments as on *S. spinosus*.

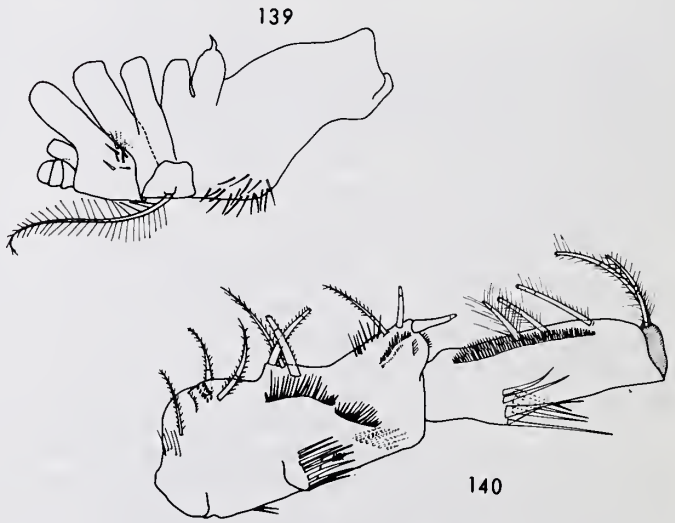
P1 as on *S. spinosus*.

Male.—Unknown.

Remarks

Park (1970) described a new species, *S. pteronus*, apparently differing from *S. usitatus* only by the presence, in *S. pteronus*, of laterally extended edges of Ce. Ce of many *Spinocalanus* species has a tendency to bend up along the lateral edge; sometimes only one side is affected. This may be a reaction to the fixative, or it may be a function of age of the specimen. Ce of the holotype *S. usitatus* is turned out in this way on the left side. Therefore, since the present study considers that *S. pteronus* is essentially defined by a possible artifact, the name *S. usitatus* ("usitatus" = ordinary, usual) is retained for the species.





***Spinocalanus usitatus*, female**

Figure 137.—Habitus, dorsal view; sample 31; scale A.
Figure 138.—Habitus, lateral view; sample 31; scale A.
Figure 139.—Mx2, inner and terminal setae omitted; sample 31; scale D.
Figure 140.—Mxp B1-2; sample 31; scale D.

Distribution

Vervoort (1946) reported one female (1.80 mm) *S. spinosus* with Mxp B1 with transverse spine-comb, in that it agreed with Mxp described by Wolfenden (1911) for *S. horridus*. Vervoort's specimen is considered to be *S. usitatus*. Roe (1972a, b) reported *S. spinosus* from the east Atlantic and remarked that some of them may be closely related species as described by Park (1970).

Pacific Ocean
  Northeast: Present study, 300-400 m.
  Central: Present study, 0-1,000 m.
Indian Ocean
  Northwest: Vervoort (1946), 555-1,000 m.
Atlantic Ocean
  Caribbean Sea: Park (1970), 487-1,900 m.

38. *Spinocalanus hoplites* Park, 1970

Spinocalanus hoplites Park, 1970, p. 489, fig. 55-58.

TYPE SPECIMEN: Holotype, female (1.72 mm), USNM 123781.
TYPE LOCALITY: Caribbean Sea, 980-1,900 m.
MATERIAL STUDIED: Holotype, female (1.72 mm) and 3 paratypes, females (1.52, 1.60, 1.62 mm), sample 56 (Table 3).

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.52-1.78 mm. Similar to *S. spinosus* except Mxp B1 with transverse spine-comb. Differs from *S. usitatus* in that Mxp B1 spine-comb on very large tubercle, and Mx2 posterior surface of lobe-5 base without spines.

Male.—Unknown.

Remarks

The development of a transverse spine-comb on Mxp B1, in those species where it occurs, is variable; it is sometimes reduced or even lacking on Mxp of one side. Likewise, the spine-comb base is more or less prominent, and in *S. hoplites* is very pronounced. If it were not for the absence of spines on base of Mx2 lobe-5, *S. hoplites* would be considered in this study as equivalent to *S. usitatus*.

Distribution

Atlantic Ocean
  Caribbean Sea: Park (1970), 980-2,800 m.

39. *Spinocalanus aspinosus* Park, 1970

Spinocalanus aspinosus Park, 1970, p. 489, fig. 59-61.

TYPE SPECIMEN: Holotype, female (1.38 mm), USNM 123780.
TYPE LOCALITY: Caribbean Sea, 1,004-1,850 m.
MATERIAL STUDIED: 1 female (1.41 mm), sample 53 (Table 3); holotype, female (1.38 mm), sample 54; 1 female (1.48 mm, after Park, 1970), on slide, sample 57.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.32-1.48 mm. Similar to *S. hoplites* except Th1-Th4 without lateral spinules. Mxp B1 with transverse spine-comb on conspicuous tubercle.

Male.—Unknown.

Remarks

Two of the specimens examined in this study had been reported as *S. brevicaudatus* by Park (1970).

Distribution

Atlantic Ocean
  Caribbean Sea: Park (1970), 980-1,900 m.
    —Present study, 203-1,000 m.

Grice and Hulsemann (1965) reported some *S. spinosus* without integumental spinules from the northeast Atlantic. Probably those specimens belonged to *S. aspinosus*.

40. *Spinocalanus oligospinosus* Park, 1970

(Figure 158)

?*Spinocalanus caudatus* Sars, 1920, p. 3. —Sars, 1924, 1925, p. 31-32, pl. 8, fig. 10-17. —Rose, 1933, p. 85-86, fig. 45.
Spinocalanus oligospinosus Park, 1970, p. 491, fig. 62-65.
Spinocalanus paraoligospinosus Hure and Scotto di Carlo, 1971, p. 584-585, nomen nudum.
Spinocalanus neospinosus Grice, 1971, p. 276-280, fig. 2A-I.

TYPE SPECIMEN: Holotype, female (1.28 mm), USNM 123782.
TYPE LOCALITY: Caribbean Sea, 487-950 m.
MATERIAL STUDIED: Holotype, female (1.28 mm), sample 55 (Table 3). Also the type specimen of *S. neospinosus*: holotype, female (1.30 mm), sample 47.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

Female.—Length 1.20-1.50 mm. Similar to *S. usitatus* except *S. oligospinosus* Mx2 lobe-5 base without spines, and lateral prosomal spinules less numerous on right side. Left Th1, many distinct spinules; Th2-Th3, ca. 25 spinules; Th4, no spinules. Right Th1, many distinct spinules; Th2 few spinules; Th3-Th4, no spinules.

A1 terminal segments (Fig. 158) of moderate length and width. Apparent deviation: I-2s; remainder as Table 4.

Mxp B1 spine-comb sometimes somewhat reduced on one side; holotype with distinct spine-comb left and right.

P3 Re3 with 5 inner setae, not 4 as shown by Park (1970, fig. 65).

Male.—Unknown.

Remarks

Sars (1920; 1924, 1925) described *S. caudatus* from one female collected in the western Mediterranean. Rose (1933) and Massuti (1939) cited this single record. This species has not been reported from the Mediterranean since the original record. It is possible that *S. caudatus* is conspecific with *S. brevicaudatus*, which has *not* been reported from the Mediterranean. It is also possible that *S. caudatus* is conspecific with *S. oligospinosus* which is common at the type locality of *S. caudatus*. Sars' (1924, 1925) description does not mention lateral prosomal spinules or Mxp B1 spine-comb, both of which could have been overlooked. The prosome/urosome ratio of *S. caudatus* is consistent with that of *S. oligospinosus* but not of *S. brevicaudatus*. The description is not precise enough to separate *S. caudatus* from other species; in this study, Sars' specimen is considered *S. oligospinosus*. The holotype *S. caudatus*, in poor condition, is on slide F5038, OSLO.

Hure and Scotto di Carlo (1971) equated their earlier use of *S. abyssalis* with Grice's manuscript name for *S. neospinosus*, *S. paraoligospinosus* (G. Grice, pers. commun.).

Grice (1971, fig. 2E, G) did not note the presence of 4 posterior surface spines on P1 Re3, and P3 Ri3 has 6 setae.

Distribution

Atlantic Ocean

Mediterranean Sea: ?Sars (1920), 0-2,595 m. —Hure (1965), 200-1,000 m. —Hure and Scotto di Carlo (1968, 1969, 1971), 300-1,000 m. —Scotto di Carlo (1968), 200-1,000 m. —Grice (1971), 750-2,200 m.

Caribbean Sea: Park (1970), 203-1,000 m.

Wilson (1942) reported *S. caudatus* in seven samples from the northeast and central Pacific. Wilson's samples 87 and 132 were examined in the present study and found not to contain any Spinocalanidae. The other samples were not located.

Furuhashi (1966) reported six female *S. caudatus* from the northwest Pacific; he also reported *S. brevicaudatus* (as *S. pseudospinipes*) from the same area, and perhaps the *S. caudatus* are *S. brevicaudatus*.

(41. *Spinocalanus paraoligospinosus* Hure and Scotto di Carlo, 1971, nomen nudum)

See *Spinocalanus oligospinosus* Park, 1970.

(42. *Spinocalanus neospinosus* Grice, 1971)

See *Spinocalanus oligospinosus* Park, 1970.

43. *Spinocalanus terranovae*, new species

(Figures 141-147, 159)

Spinocalanus abyssalis. —Bradford, 1971 (part), p. 17, fig. 22-27; 1.7-2.0 mm only. Not *S. abyssalis* Giesbrecht, 1888.

TYPE SPECIMEN: Holotype, female (1.88 mm), BM 1930.1.1.293-404.a.

TYPE LOCALITY: Antarctic, Pacific Sector, 0-400 m.

MATERIAL STUDIED: Holotype, female (1.88 mm) and 3 paratype females (1.85, 1.95, 1.98 mm), sample 6 (Table 3); 1 female (1.9 mm, after Bradford, 1971), on slide, sample 8; 1 paratype female (1.75 mm), sample 9, USNM 142701; 1 paratype female (1.80 mm), sample 9, NZOI P261; 1 paratype female (2.0 mm, after Bradford), on slide, sample 9, NZOI P261; 1 paratype female (1.8 mm, after Bradford), on slide, sample 10, NZOI P261; 1 paratype female (1.75 mm, after Bradford), on slide, sample 12, NZOI P261; 1 male (1.9 mm, after Bradford), on slide, sample 12, NZOI P261.

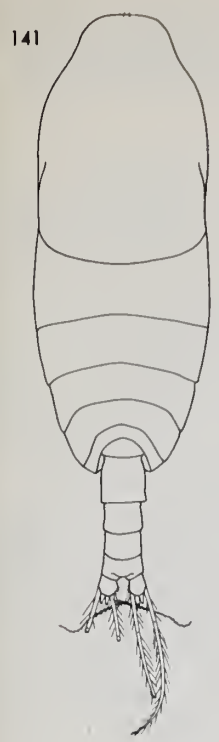
Description

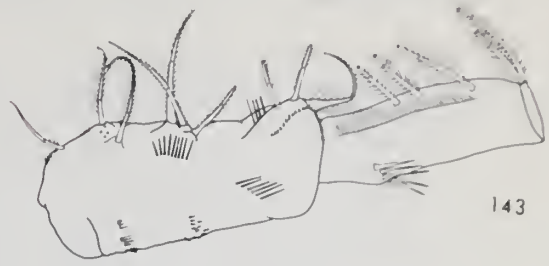
P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta.

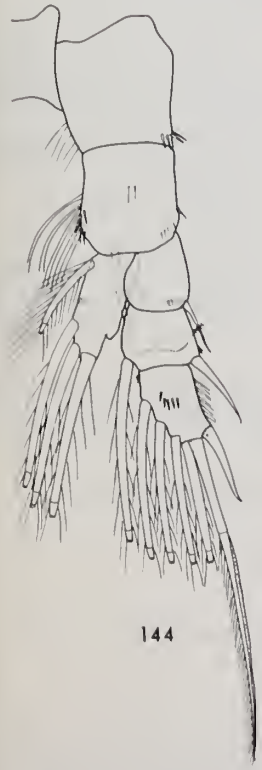
Female.—Length (1.65?-) 1.70-2.20 mm (Figs. 141, 142). Prosome in dorsal view ovoid, head slightly truncate. In lateral view with moderately gentle forward slope. Th4 and Th5 separate; Th5 lateral corners rounded, not prolonged; Th1-Th4 without lateral spinules. Prosome length about 3⅓ times urosome. Genital segment as wide as long, protruding ventrally one-third depth of rest of urosome; caudal rami length slightly greater than width, symmetrical. Caudal setae incomplete on specimens examined; bases appearing symmetrical.

Spinocalanus terranovae, female

Figure 141.—Habitus, dorsal view; sample 6 (Table 3); scale A.
Figure 142.—Habitus, lateral view; sample 6; scale A.
Figure 143.—Mxp B1-2; sample 6; scale D.
Figure 144.—P1; sample 6; scale D.
Figure 145.—P2; sample 6; scale D.
Figure 146.—P3; sample 6; scale D.
Figure 147.—P4; sample 6; scale D.







A1 exceeding caudal rami by nearly 2 segments; terminal segments (Fig. 159) of moderate length and width. Apparent deviation: I-2s; remainder as Table 4.

A2 Re1 with 2 setae.

Mn B2 inner distal anterior surface and Ri1 surface with long setules. Blade broken on specimens examined.

Mx1 gnathobase posterior surface apparently with 3 proximal setae; without seta on distal anterior surface.

Mx2 with proximal setule-covered hump and outer seta; posterior surface of lobe-5 base without spines.

Mxp (Fig. 143) B1 without spine-comb; anterior surface with several rows of short to long setules; distal lobe with ascending oblique row of denticles followed by descending row of short stiff hairs. B2 outer edge with transverse spine-comb; longitudinal row of stiff hairs. Ri4-5 outer setae nude, bladelike, tapering toward each end; spinules on inner edge of Ri5.

P1 (Fig. 144) B1 outer distal edge with few spines, inner margin with hairs. B2 inner surface with spines and inner margin with hairs; anterior surface with few central setules and outer distal row of spinules. Re1 outer spine reaching base of following spine; Re2 outer spine reaching beyond base of following spine. Re1 anterior surface with outer distal row of spinules. Re3 midposterior surface with 4-7 spines.

P2 (Fig. 145) B1 inner and outer surface with rows of strong spines; inner margin with hairs. Re3 without proximal row of spines; midlength row with 5-6 spines; distal row with 4-6 spines.

P3 (Fig. 146) B1 inner and outer surface with rows of strong spines; inner margin with hairs. Re2 posterior surface with proximal row of strong wide spines and distal row of denticles. Re3 posterior surface with 3 evenly spaced rows of spines; spines increasing in width and decreasing in number distally. Ri3 posterior surface with proximal row of 7-9 spines and distal row of 3-5 stronger spines.

P4 (Fig. 147) B1 proximal outer surface with few rows of spines, smaller than on P2-P3; inner surface with setules. B2 posterior surface with inner transverse row of spinules as on *S. horridus* and *S. spinosus*. Re2 posterior surface with proximal row of strong wide spines and distal row of small spines. Re3 posterior surface with 3 evenly spaced rows of spines.

Re terminal seta with the following number of teeth: P2 (30-34); P3 (28-29); P4 (33-38).

Male.—Length 1.70-1.9 mm. Some A1 segments damaged on specimen examined: IV-2s, 2e; VIII-2s, 2e; XV-?1s, 1e; XIX-1s, 1e; right XX-0; left XX-1e.

Mxp Ri5 inner edge with spinules.

Other details known only from one damaged specimen reported by Bradford (1971). P1 Re3 posterior surface with spines. P4 B1 with inner seta (Bradford, fig. 26). P5 shown by Bradford (fig. 22), incomplete; biramus, left-handed. Left B1 reaching middle of right B2; left B2 reaching nearly to end of right Re1. Ends of Re long terminal setae and Ri broken. Both Ri presumably reaching beyond Re3.

Remarks

Farran (1929) reported a group of large (1.8-2.06 mm) *S. abyssalis* from the Pacific Sector of the Antarctic. Some of these specimens were examined in the present study (sample 6, Table 3) and were found to be a new species, *S. terranovae*, described above.

Vervoort (1951) reported three female *S. abyssalis* from the Atlantic Sector of the Antarctic. His specimens are considered *S. terranovae* in the present study, although they might be *S. brevicaudatus* or other species. The smallest specimen, 1.65 mm, is tentatively included in the length range of females.

Vervoort's (1957) specimens of *S. abyssalis* are considered *S. terranovae* in the present study. The length range of males reported by Vervoort (1.70-1.85 mm) is included in the above description. Vervoort's list of specimens from each sample indicates one male 2.20 mm, but this most likely should read "female."

Bradford (1971) reported two size groups of *S. abyssalis*; only the larger was *S. terranovae*, the smaller was *S. abyssalis* Giesbrecht.

Distribution

Probable records of *S. terranovae*, previously known as a large *S. abyssalis*, are summarized below:

Antarctic
- Pacific Sector: Farran (1929), 0-1,750 m. —Vervoort (1957, 1965), 250-1,000 m. —Bradford (1971), 0-1,300 m.
- Indian Sector: Vervoort (1957, 1965), 100-1,500 m. —Tanaka (1960), 0-400 m.
- Atlantic Sector: Vervoort (1951), 0-900 m.

Hardy and Gunther (1935) reported a *Spinocalanus* species from the South Atlantic (300-2,000 m) which might be *S. terranovae*.

Etymology: The specific name, *terranovae*, from the British Antarctic ("Terra Nova") Expedition, 1910.

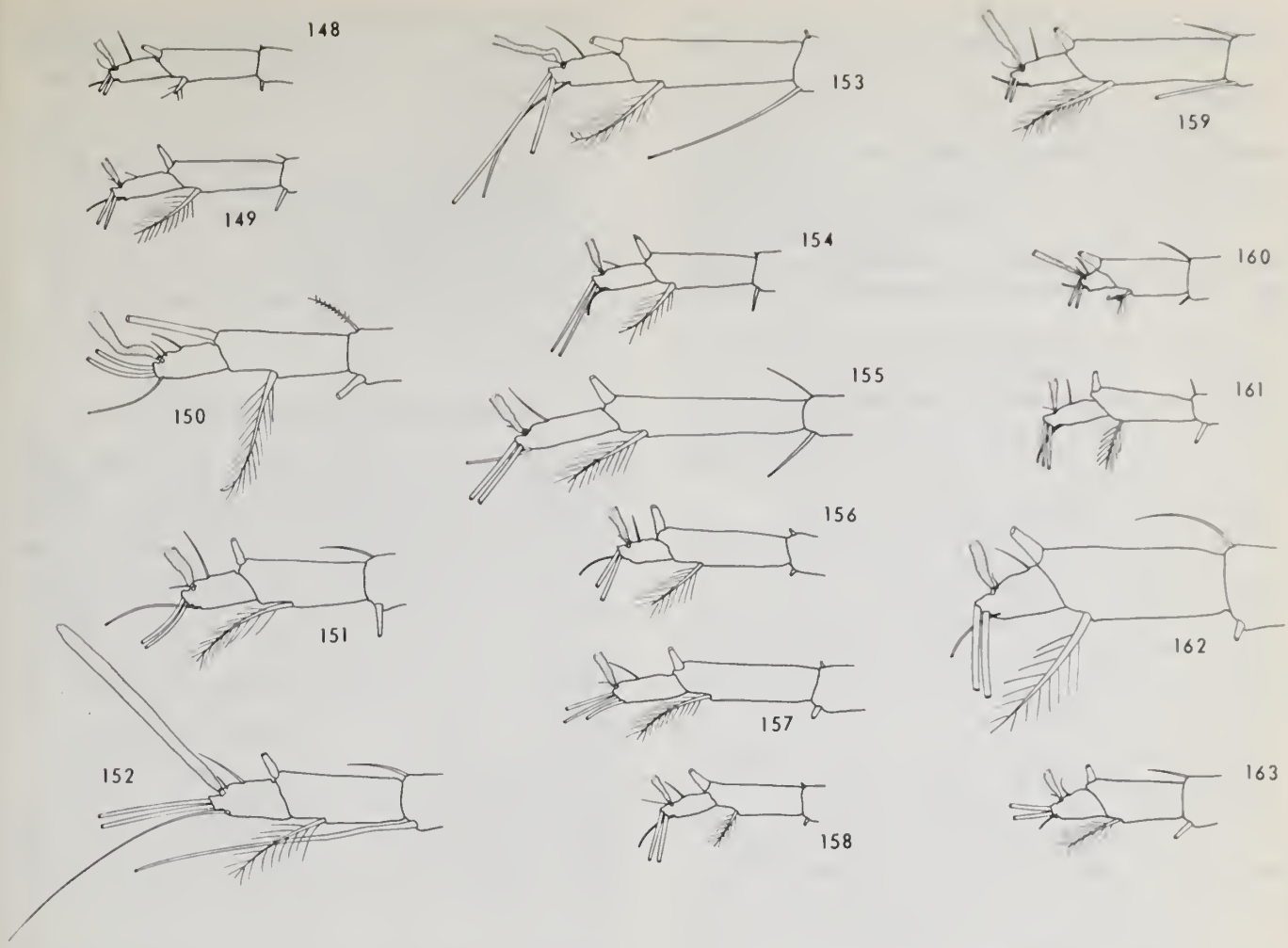
Genus *Monacilla* Sars, 1905

Oxycalanus Farran, 1908.
Hypsicalanus Wolfenden, 1911.

Type Species: *Monacilla typica* Sars, 1905.

Description

Rostrum 2-pointed. P1 Re1 with outer distal spine, reduced in male; Re1-2 together longer than Re3; *Ri with 3 inner setae. P2 Ri2 with 1 outer seta. P3-P4 Ri3 with 2 outer setae. Posterior surface of certain*



Terminal segments of first antenna, female

Figure 148.—*Spinocalanus abyssalis*: sample 11 (Table 3); scale D.
Figure 149.—*Spinocalanus longicornis*: scale D.
Figure 150.—*Spinocalanus magnus*: sample 41; scale D.
Figure 151.—*Spinocalanus antarcticus*: sample 9; scale D.
Figure 152.—*Spinocalanus antarcticus*: scale D.
Figure 153.—*Spinocalanus horridus*: scale D.
Figure 154.—*Spinocalanus similis*: sample 30; scale D.
Figure 155.—*Spinocalanus elongatus*: scale D.
Figure 156.—*Spinocalanus polaris*: scale D.
Figure 157.—*Spinocalanus brevicaudatus*: sample 16; scale D.
Figure 158.—*Spinocalanus oligospinosus*: sample 47; scale D.
Figure 159.—*Spinocalanus terranovae*: sample 6; scale D.
Figure 160.—*Mimocalanus ovalis*: sample 48; scale D.
Figure 161.—*Mimocalanus crassus*: scale D.
Figure 162.—*Mimocalanus sulcifrons*: scale D.
Figure 163.—*Mimocalanus heronae*: sample 31; scale D.

segments of swimming legs with rows of spines (see below). Caudal rami and caudal setae symmetrical.

Female.—Prosome in dorsal view slender to robust ovoid, head rounded or with prominent crest. Rostrum 2 sharp, vertically directed, spines; sometimes asymmetrical. Th5 lateral corners prolonged; Th1-Th4 without lateral spinules. Prosome length 3-3½ times urosome. Genital segment sometimes asymmetrical; protruding ventrally one-half depth of rest of urosome. Caudal rami length 1½-2 times width.

A1 segment 2 length at least 1½ times segment 1; segments 8 and 9 fused.

A2 Re length exceeding Ri by about 20%. Published information on A2 segmentation contradictory; probably Re2 with 2 setae and at least partly fused with Re3.

Mn B2 with 4 inner setae.

Mx1 gnathobase as in *Spinocalanus*; distal anterior seta apparently absent. Inner lobe-1 with 5 setae. Outer lobe-2 small, with 1 short seta.

Mx2 length 1½ times width; proximal outer hump nude. Lobe-5 with 4 strong setae; posterior surface of base without spines. Lobe-6 small, with 2 setae. Ri segments not reduced. Mx2 outer seta apparently absent.

Mxp B1 with or, apparently, without transverse spine-comb midlength on outer anterior and posterior edge. B2 without spine-comb. B1 with proximal and midlength group of 3 setae each; distal group apparently with 4-6 setae. B2 with longitudinal row of stiff hairs; 2 setae about midlength, 1 seta more distal, and 2 distal setae. Ri4-5 outer setae relatively short and thin, probably lightly plumose; Ri5 inner edge without spinules.

P1 Re3 apparently without posterior surface spines.

P2-P3 Re2 posterior surface probably with row of small spines; P4 Re2 with 2 rows of spines.

P2-P3 Re3 posterior surface probably with 2 distal rows of spines. P4 Re3 posterior surface with longitudinal series of small spines.

P2-P4 Re terminal seta with finely serrate outer edge; outer flange narrow.

P2-P4 Ri2 posterior surface with 2 rows of spines. P3-P4 Ri3 posterior surface with 2 rows of spines.

P4 B1 with transverse row of long spinules on inner posterior surface; length variable, sometimes asymmetrical or lacking on right.

Male.—Adult known only for *M. typica.* See also *Monacilla* sp. (= *M. typica.*—Wheeler, 1970).

Key to the Species of *Monacilla*

1. *Female*: Prosome slender ovoid, anterior crest. (Male unknown.) . . . . . 2. *M. tenera*
   Female: Prosome robust ovoid, no anterior crest . . . . . (2)
2. *Female*: Genital segment symmetrical, not protruding on right; P4 B1 inner posterior surface with transverse row of spinules, equal length left and right. (Male unknown.) . . . . . 7. *M. gracilis*
   Female: Genital segment asymmetrical, protruding on right; P4 B1 inner posterior surface with transverse row of spinules, longer on left, sometimes absent on right. *Male*: Length 1.59-2.3 mm. P1 Re1 outer spine reduced to minute seta; P1 Re2 outer spine forming sharply curved hook; P5 left Ri styliform . . . . . 1. *M.typica*

1. *Monacilla typica* Sars, 1905

Monacilla typica Sars, 1905, p. 9. —Sars, 1924, 1925, p. 38-40, pl. 11, fig. 1-15; pl. 12, fig. 1-10. —Rose, 1933, p. 87-88, fig. 49. —Vervoort, 1946, p. 158-163. —Wilson, 1950, p. 267, pl. 26, fig. 380. —Farran and Vervoort, 1951b, p. 2-3, fig. 3b-e, h-i. —Tanaka, 1956, p. 396-397, fig. 18. —Owre and Foyo, 1967, p. 42, fig. 88, 92, 226-227, 229-230. —Grice, 1971, p. 276-279, fig. 2J-K, 3A-B.

Oxycalanus spinifer Farran, 1908, p. 25-27, pl. 1, fig. 11-17.

Oxycalanus semispinus Scott, 1909, p. 33-34, pl. 2, fig. 9-21.

Monacilla dubia Scott, 1909, p. 35-36, pl. 3, fig. 17-29.

Monacilla semispina. —Wilson, 1950, p. 266-267, pl. 26, fig. 379.

Monacilla typica var. *asymmetrica* Tanaka, 1956, p. 398, fig. 19.

Type Specimens: Syntypes, females (2.30 mm), Musée Océanographique de Monaco (Belloc, 1960); on slides F5052-F5058, OSLO.

Type Locality: East and northeast Atlantic, 1,000-1,200 m.

Material Studied: 1 male (1.75 mm), sample 39 (Table 3); 1 male (1.72 mm), sample 40.

Description

Female.—Length 1.95-2.5 mm. Prosome in dorsal view robust ovoid; head rounded, without crest. In lateral view with fairly abrupt forward slope. Rostrum 2 sharp, vertically directed spines, symmetrical. Prosome length 3½ times urosome. Genital segment asymmetrical, somewhat protruding on right. Caudal rami length 1½ times width.

A1 reaching anal segment.

Mxp B1 with transverse spine-comb midlength on outer edge. B2 with cluster of spinules about one-third length on outer edge.

P4 B1 transverse row of long spinules on inner posterior surface more developed on left, sometimes lacking on right.

[Sars (1905, 1925) reported P5 as reduced to simple

spine or absent. No other worker has mentioned female P5, and most have stated P5 absent.]

Male.—Length 1.59-2.3 mm. Prosome ovoid, anterior irregular in dorsal view, posterior somewhat rounded; in lateral view with abrupt forward slope. Rostrum knoblike protuberance, faintly divided. Ce and Th1 separate; Ce slightly expanded dorsally but not posteriorly. Prosome length 2½ times urosome. Anal segment reduced. Caudal rami length slightly greater than width. Caudal setae relatively thick.

A1 reaching urosome segment 3. Segment 2 somewhat longer than segment 1; segments 9 and 10 fused. Right segment 20 merging with segment 21, as on left-handed species; segment 25 reduced.

Mx2 fragile, surface nude; setae of reduced length, terminal setae thicker than on female.

Mxp B1-2 surface nude, setae of reduced size. Ri1 partly fused to Ri2. Ri1 with 4 short, plumose setae. Ri2 twice as long as on female, setae of reduced size. Ri3 proximal seta reduced; other 2 setae long, thick, with rough and shortly plumose inner edge. Ri4 inner setae as Ri3, outer seta reduced. Ri5 reduced, all setae reduced.

P1 Re1 outer distal spine reduced to minute seta. Re2 outer distal spine forming sharply curved hook.

P4 B1 posterior surface without inner transverse row of spinules or setules; inner margin with seta.

P5 biramus, left-handed; left B1 reaching one-third length of right B2; left B2 reaching one-third length of right Re2. Left leg slightly longer than right; left and right Re about equal length; left Ri much longer than right Ri. Order of length, longest to shortest, of Re segments: left 3, 2, 1; right 2 = 3, 1. Left Ri reaching about to end of left Re longest terminal seta. Right Ri reaching one-third length of right Re2. At least right Re1 with distal outer seta. Inner edge of left Re2-3 with hairs. Each Re with 1 small and 1 moderate bladelike terminal setae.

Remarks

Sars (1905) originally reported female *M. typica* length as 2.20 mm; apparently this was an error, corrected to 2.30 mm (Sars, 1925; Belloc, 1960).

Sars' (1924, 1925) later description is thorough; however, he undoubtedly failed to note spines on the posterior surface of P2-P4, described by other workers.

The descriptions by Rose (1933), Farran and Vervoort (1951b), and Owre and Foyo (1967) are from Sars (1924, 1925).

Distribution

Pacific Ocean
- Northwest: Tanaka (1953, 1956), 0-1,000 m. —Furuhashi (1961, 1966), 369-3,010 m. —Minoda (1971), 87-164 m.
- West: Wilson (1950), 0-180 m.
- Indo-Pacific: Scott (1909), 0-2,000 m. —Vervoort (1946), 355-1,800 m. —Wilson (1950), 0-1,080 m.

Indian Ocean
- Northwest: Vervoort (1946), 555-1,000 m.
- West: Grice and Hulsemann (1967), 1,000-2,000 m.
- Southwest: De Decker and Mombeck (1965), 500-1,500 m.

Atlantic Ocean
- North: Grice and Hulsemann (1965), 850-1,400 m.
- Northeast: Sars (1905; 1924, 1925), 0-2,500 m. —Farran (1908, 1926), 450-1,800 m. —Lysholm and Nordgaard (1945), 0-1,700 m. —Grice and Hulsemann (1965), 1,000-2,800 m. —Vives (1970), 300-900 m.
- East: Sars (1905; 1924, 1925), 0-5,000 m. —Lysholm and Nordgaard (1945), 0-3,400 m. —Vervoort (1963), 0-100 m. —Roe (1972a, b), 830-950 m.
- Mediterranean Sea: Sars (1924, 1925), cited by Massuti (1939), 0-2,595 m. —Hure (1965), 300-1,000 m. —Hure and Scotto di Carlo (1968, 1969, 1971), 300-1,000 m. —Mazza (1968), 250-700 m. —Scotto di Carlo (1968), below 300 m. —Grice (1971), 850-2,200 m.
- Southeast: Unteruberbacher (1964), 0-52 m.
- Central: Lysholm and Nordgaard (1945), 0-1,250 m.
- West: Grice (1963), 600-1,000 m.
- Caribbean Sea: Owre and Foyo (1964), 584-877 m. —Park (1970), 487-1,900 m.

2. *Monacilla tenera* Sars, 1907

Monacilla tenera Sars, 1907, p. 6. —Sars, 1924, 1925, p. 40-41, pl. 12, fig. 11-18. —Farran, 1926, p. 245-246, pl. 6, fig. 13-14. —Rose, 1933, p. 88, fig. 50. —Farran and Vervoort, 1951b, p. 2-3, fig. 4a-b. —Owre and Foyo, 1967, p. 42, fig. 224-225, 228, 231-232.

Hypsicalanus gracilis Wolfenden, 1911, p. 219-220, pl. 25, fig. 6-11.

TYPE SPECIMENS: Syntypes, females (2.30 mm), Musée Océanographique de Monaco (Belloc, 1960); on slides F5059-F5061, OSLO.

TYPE LOCALITY: Central North Atlantic, 0-3,000 m.

Description

Female.—Length 1.8-2.30 mm. Prosome in dorsal view slender ovoid; head with prominent crest. In lateral view, crest with abrupt forward slope. Rostrum 2 sharp, vertically directed spines, left longer than right (Sars, 1925; Sars, 1907, first reporting right longer than left). Prosome length 3 times urosome. Genital segment symmetrical. Caudal rami length 2 times width.

A1 reaching anal segment.

Mxp B1 apparently without transverse spine-comb.

P4 B1 reported by Sars (1925) to lack transverse row of spinules on inner posterior surface; row of spinules reported by Wolfenden (1911).

Male.—Adult unknown. [Owre and Foyo (1967) briefly described one male stage V (size not reported). Urosome was reported with 5 segments, which would indicate an adult specimen, but the illustrated P5 suggest stage V male. The crest and rostrum were as on adult female.]

Remarks

Sars (1907) originally reported female *M. tenera* length as 2.20 mm; apparently this was an error, corrected to 2.30 mm (Sars, 1925; Belloc, 1960).

The descriptions by Rose (1933) and Farran and Vervoort (1951b) are from Sars (1924, 1925).

Distribution

Indian Ocean
- Northwest: Sewell (1929), 1,260 m.
- West: Grice and Hulsemann (1967), 1,000-2,000 m.
- Southwest: De Decker and Mombeck (1965), 1,000-1,500 m.

Atlantic Ocean
- Northeast: Farran (1926), 900-3,600 m.
- East: Grice and Hulsemann (1965), 1,000-2,800 m.
- Central: Sars (1907; 1924, 1925), 0-3,000 m. —Wolfenden (1911). —Wheeler (1970), 2,000-4,000 m.
- Northwest: Wheeler (1970), 2,000-4,000 m.
- Caribbean Sea: Owre and Foyo (1964, 1967), 877-1,500 m. —Park (1970), 203-1,900 m.

(3. *Oxycalanus spinifer* Farran, 1908)

See *Monacilla typica* Sars, 1905.

(4. *Oxycalanus semispinus* Scott, 1909)

See *Monacilla typica* Sars, 1905.

(5. *Monacilla dubia* Scott, 1909)

See *Monacilla typica* Sars, 1905.

(6. *Hypsicalanus gracilis* Wolfenden, 1911)

See *Monacilla tenera* Sars, 1907.

7. *Monacilla gracilis* (Wolfenden, 1911)

Oxycalanus gracilis Wolfenden, 1911, p. 221-222, fig. 10; pl. 25, fig. 12-14.

Monacilla gracilis. —Tanaka, 1956, p. 398-399, fig. 20.

TYPE SPECIMEN: Unknown.

TYPE LOCALITY: Central Atlantic, 0-3,000 m.

Description

Female.—Length 1.8-2.25 mm. Similar to *Monacilla typica*, except genital segment symmetrical, and transverse row of long spinules on inner posterior surface of P4 B1 equal length left and right, reaching beyond distal edge of B1.

Male.—Unknown.

Remarks

M. gracilis had been considered a synonym of *M. typica*. Tanaka (1956) reported one specimen which he considered *M. gracilis*, a distinct species. Vervoort (1963) pointed out that Tanaka's specimen may be distinct, but that it can only be referred to Wolfenden's *M. gracilis* with some reservations.

Distribution

Pacific Ocean
- Northwest: Tanaka (1953, 1956), 0-1,000 m.

Atlantic Ocean
- Central: Wolfenden (1911), 0-3,000 m.

(8. *Monacilla typica* var. *asymmetrica* Tanaka, 1956)

(*M. typica* var. *asymmetrica* Tanaka, 1953, nomen nudum)

See *Monacilla typica* Sars, 1905.

9. *Monacilla* sp.

Monacilla typica.—Wheeler, 1970, p. 9, fig. 21-22. Not *M. typica* Sars, 1905.

Remarks

Wheeler (1970) reported one male (1.01 mm) as *M. typica*. P5 were damaged, but apparently differed from *M. typica* P5. This specimen, as well as other small *Monacilla* males, should be reexamined. Vervoort (1946) reported one male (also 1.01 mm) as *M. typica*; it may be the same species as Wheeler's specimen. No females can at present be assigned to this species.

Distribution

Pacific Ocean
Indo-Pacific: ?Vervoort (1946), 1,845-2,500 m.
Atlantic Ocean
West: Wheeler (1970), 2,000-4,000 m.

GENUS *MIMOCALANUS* FARRAN, 1908

TYPE SPECIES: *Mimocalanus cultrifer* Farran, 1908.

Description

Rostrum absent. P1 Re1 without outer distal spine; Re1-2 together longer than Re3; *Ri with 1-2 inner setae. P2 Ri2 with 0-1 outer seta.* P3-P4 Ri3 with 0-1 outer seta. *Surface of swimming leg segments without spines.* Caudal rami symmetrical. Caudal setae usually incomplete on specimens examined: no trace of outer (sixth) seta; outer and inner terminal setae usually completely detached; middle 2 terminal setae usually broken at bases; inner seta directed ventrally, small or reduced.

Female.—Prosome in dorsal view slender to robust ovoid. Most species with distinct indented sclerotization about midlength on Ce; sclerotization direct extension of sclerotized supporting margin of labrum, and perhaps serving as strengthened attachment for mandibular muscles. (Sclerotization reduced in adult males, where mandible also reduced.) Th5 lateral corners prolonged, at least to midgenital segment. Th1-Th4 without lateral spinules. Prosome length nearly 4 to nearly 5 times urosome. Caudal rami length 1-1½ times width.

A1 segment 2 length about equaling segment 1 (*M. ovalis* segment 2 length about 1½ times segment 1). Segments 8 and 9 partly fused (completely fused on *M. ovalis*). A1 narrowing between segments 9-11. A1 exceeding caudal rami by 1-4 segments (only reaching genital segment on *M. ovalis*). Armature as in *Spinocalanus* female (Table 4). Esthete bases smaller than on *Spinocalanus* female.

A2 (Fig. 194) Re length exceeding Ri by 20%. *Re1 without setae. Re2 and Re3 separate*; *Re2 without setae.*

Mn B2 with 2 or 3 inner setae, surface nude. Ri1 surface nude.

Mx1 gnathobase proximal surface without spinules; distal anterior seta present. Inner lobe-1 with 4 setae; inner lobes-1-2 relatively large. Proximal part of Ri with 3 or 7 proximal and 3 or 7 distal setae. Small nude outer lobe-2 sometimes present.

Mx2 (Fig. 197) length 2 times width; without proximal outer hump. Lobe-5 with 3 strong and 1 reduced setae; posterior surface of base without spines. Lobe-6 reduced, apparently with only 1 seta. Ri segments reduced. Mx2 outer seta apparently absent.

Mxp B1-2 without transverse spine-comb. B1 with proximal group of 2 setae, midlength group of 3 setae, and distal group of 3 or 4 setae. B2 with longitudinal row of reduced spinules or denticles (*M. ovalis* with stiff hairs); 3 setae about midlength and 2 distal setae (*M. ovalis* with 2 setae midlength, 1 seta more distal, and 2 distal setae). Ri4-5 outer setae usually moderately long, with very long plumes each side; Ri5 inner edge without spinules.

P2-P4 Re terminal seta with finely serrate outer edge (48-90 teeth); outer flange wide.

P4 B1 transverse row of thin setules on posterior surface proximal to inner seta (*M. crassus* without transverse row of setules and without inner seta).

Male.—Prosome in dorsal view elongate to robust ovoid; anterior varying with species. Reduced sclerotization midlength on Ce in adult; male stage V sclerotization as on adult female. Ce not expanded. Ce and Th1 separate. Prosome length 2¾-3¾ times urosome. *Anal segment not reduced*, length ⅔-1 times caudal ramus. Caudal rami length 1-1½ times width.

A1 segment 2 length about equaling segment 1; segment 10 partly fused with segment 9; right segment 20 merging with segment 21, as on other left-handed species; segment 25 not reduced. A1 narrowing between segments 8-10. Esthete bases very small. Armature given in Table 4.

Swimming legs generally similar to those on corresponding female. P4 B1 without inner transverse row of setules on posterior surface; some species with inner seta.

P5 uniramus, left-handed, variably asymmetrical; Re essentially 3-segmented, Re1-2 may be partly fused.

KEY TO THE SPECIES OF *MIMOCALANUS*

1. P2 Ri2 with 1 outer seta . . . . . (4)
   P2 Ri2 with no outer seta . . . . . (2)
2. P2-P3 B1 without inner seta; P3-P4 Ri3 with no outer seta . . . . . 8. *M. crassus*
   P2-P3 B1 with inner seta; P3-P4 Ri3 with 1 outer seta . . . . . (3)
3. *Female*: A1 not reaching beyond genital segment; A1 segment 2 length 1½ times segment 1. P1 Ri outer lobe reduced. (Male unknown.) . . . . . 6. *M. ovalis*
   Female: A1 reaching beyond caudal rami; A1 segments 1 and 2 lengths about equal. P1 Ri outer lobe not reduced. (Male unknown.) . . . . . 1. *M. cultrifer*
4. Length greater than 4.0 mm. (Male unknown.) . . . . . 3. *M. major*
   Length less than 4.0 mm . . . . . (5)
5. P2-P4 Ri2 with broadly inflated inner edge. (Male unknown.) . . . . . 4. *M. inflatus*
   P2-P4 Ri2 not inflated . . . . . (6)
6. *Female*: length less than 2.0 mm; Th4 and Th5 partly fused; inner caudal seta small, not re-

duced; Mxp Ri2 length more than 1½ times Ri1. *Male*: Length less than 1.5 mm . . . . . 10. *M. heronae*, new species

Female: Length greater than 2.0 mm; Th4 and Th5 separate; inner caudal seta reduced; Mxp Ri2 length less than 1½ times Ri1. *Male*: Length greater than 1.5 mm . . . . . (7)

7. *Female*: Prosome robust ovoid, Th5 lateral corners reaching midgenital segment; P1 Re2 outer spine extending two-thirds length of Re3; P2-P4 Re3 spiniform distal process about equaling size of Re3 outer distal spine; P2-P4 Re terminal seta with less than 75 teeth. *Male*: Prosome robust ovoid; P5 left Re1 longer than Re2 . . . . . .2. *M. nudus*

Female: Prosome ovoid, Th5 lateral corners reaching beyond midgenital segment; P1 Re2 outer spine reaching distal edge of Re3; P2-P4 Re3 spiniform distal process about one-half size of Re3 outer distal spine; P2-P4 Re terminal seta with more than 75 teeth. *Male*: Prosome elongate ovoid; P5 left Re2 longer than Re1 . . . . . .9. *M. sulcifrons*

1. *Mimocalanus cultrifer* Farran, 1908

(Figures 164-168)

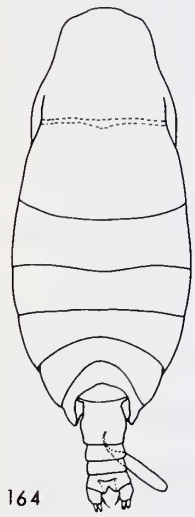
Mimocalanus cultrifer Farran, 1908, p. 23-24, pl. 1, fig. 5-9. —Rose, 1933, p. 86, fig. 47. —Davis, 1949, p. 24. —Farran and Vervoort, 1951b, p. 2-3, fig. 1a-b, d. —Vervoort, 1957, p. 42-44, fig. 11-15. —?Grice, 1971, p. 278-279, fig. 3C-D.

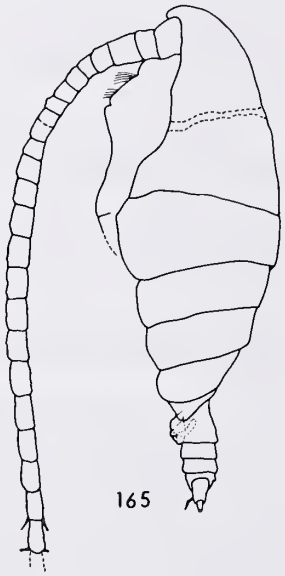
TYPE SPECIMEN: Holotype, female, BM 1908.7.6.4.
TYPE LOCALITY: Northeast Atlantic, 720-1,800 m.
MATERIAL STUDIED: 1 female (1.57 mm), sample 37 (Table 3).

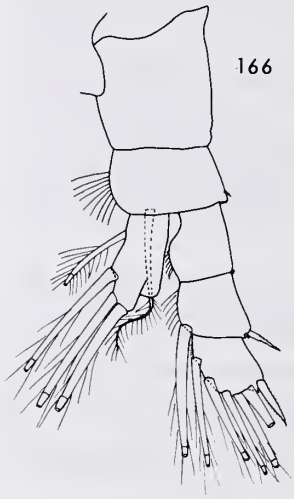
Description

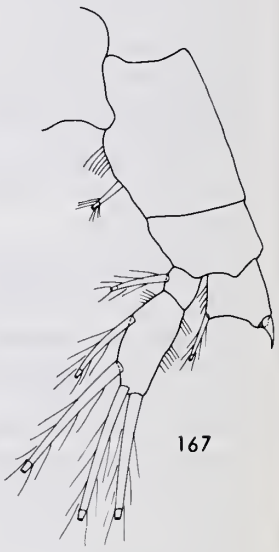
P1 Ri with 2 inner setae; P2 Ri2 with no outer seta; P3-P4 Ri3 with 1 outer seta.

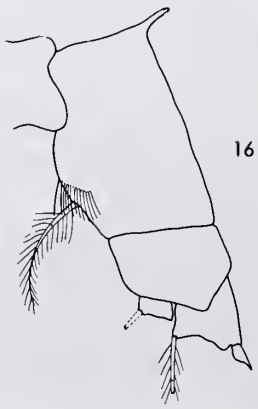
Female.—Length 1.0-1.70 mm(?) (Figs. 164, 165). Prosome in dorsal view fairly robust ovoid; head rounded, with slight bulge. In lateral view with fairly











Mimocalanus cultrifer, female

Figure 164.—Habitus, dorsal view; sample 37; scale A.
Figure 165.—Habitus, lateral view; sample 37; scale A.
Figure 166.—P1; sample 37; scale D.
Figure 167.—P2; sample 37; scale D.
Figure 168.—P4; sample 37; scale D.

abrupt forward slope. Th4 and Th5 separate. Prosome length 4 times urosome. Genital segment slightly wider than long, protruding ventrally one-third depth of rest of urosome. Caudal rami slightly longer than wide. Inner caudal seta reduced.

A1 exceeding caudal rami by 3-4 segments. Specimen examined lacked segments 24-25; remainder as Table 4.

Mn B2 with 2 inner setae (Farran, 1908).

Mx1 gnathobase apparently without proximal posterior setae.

P1 (Fig. 166) B2 and Re1 outer distal edge with 3-4 small teeth.

P2 (Fig. 167)-P4 damaged on specimen examined; described by Vervoort (1957); P4 (Fig. 168) B1 with inner transverse row of thin setules.

Male.—Undescribed. Grice and Hulsemann (1965; unpublished station list, 1966) reported a male of *M. cultrifer* (1.2 mm). Roe (1972b) reported 1 male (1.14 mm).

Remarks

Rose's (1933) and Farran and Vervoort's (1951b) descriptions are from Farran (1908); Farran and Vervoort (1951b) included length data (up to 1.91 mm) from Vervoort (1946) which probably include lengths of *M. heronae* or another species. The above description limits the length of female *M. cultrifer* to the most probable records. Vervoort (1957) did not include his earlier (1946) record in the description of *M. cultrifer*. Possibly records of small *M. cultrifer* (1.0-1.17 mm) by Vervoort (1946) and Grice and Hulsemann (1965; unpublished station list, 1966) are of *M. crassus*.

Grice's (1971, fig. 3C) lateral view of *M. cultrifer* is not as robust as other descriptions of this species (see *M. heronae*). Grice did not indicate the lengths of his specimens.

Distribution

Minoda's (1971) specimens smaller than 1.70 mm are included in the summary below; the larger specimens are considered *M. heronae*.

Pacific Ocean
- North: Minoda (1971), 743-1,230 m.
- Northeast: Davis (1949), 1,100-1,900 m. —Fleminger (1967), 0-140 m. —Present study, 1,300-1,500 m.
- Northwest: Furuhashi (1966), 252-512 m. —Minoda (1971), 195-485 m.
- Southwest: Vervoort (1957), 500-750 m.
- Indo-Pacific: Vervoort (1946), 340-1,000 m.

Indian Ocean
- West: Grice and Hulsemann (1967), 750-4,000 m.

Atlantic Ocean
- Northeast: Farran (1908, 1926), 360-1,800 m. —Grice and Hulsemann (1965), 250-4,750 m.
- East: Roe (1972a, b), 400-800 m.
- Mediterranean Sea: ?Grice (1971), 1,190-1,350 m.
- Northwest: Grice (1963), 620-1,200 m. —Wheeler (1970), 2,000-4,000 m.
- West: Wheeler (1970), 2,000-4,000 m.
- Caribbean Sea: Park (1970), 208-1,900 m.

Antarctic
- Pacific Sector: Vervoort (1957, 1965), 250-500 m.
- Indian Sector: Vervoort (1957, 1965), 500-1,000 m.

2. *Mimocalanus nudus* Farran, 1908

(Figures 169-180)

Mimocalanus nudus Farran, 1908, p. 24-25, pl. 1, fig. 1-4. —Farran and Vervoort, 1951b, p. 2-3, fig. 2b-c, e-g.

Mimocalanus distinctocephalus Brodsky, 1950, p. 136-137, fig. 56.

TYPE SPECIMENS: Syntypes, 2 females (2.30, 2.64 mm), BM 1908.7.6.5.

TYPE LOCALITY: Northeast Atlantic, 720-1,440 m.

MATERIAL STUDIED: Syntype, female (2.30 mm), sample 4 (Table 3); 1 female (2.68 mm), sample 35; 2 females (2.57, 2.65 mm) and 1 male (2.50 mm), sample 36; 4 females (2.50-2.70 mm, mean = 2.61 mm), sample 37.

Description

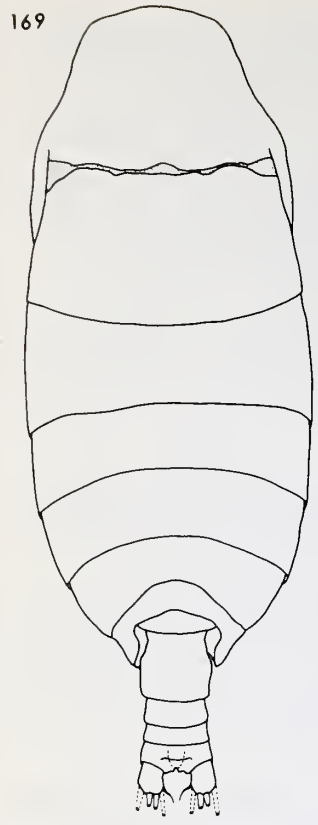
P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta; P3-P4 Ri3 with 1 outer seta.

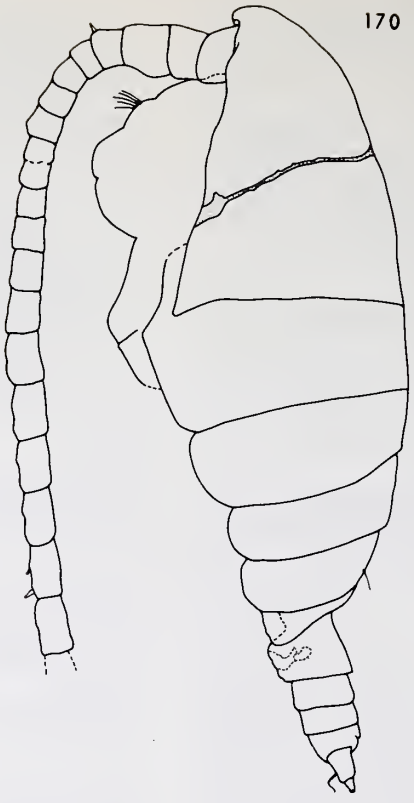
Female.—Length 2.28-2.70 mm (Figs. 169, 170). Prosome in dorsal view robust ovoid; head somewhat truncate. In lateral view with fairly abrupt forward slope. Th4 and Th5 separate. Prosome length 4 times urosome. Genital segment slightly wider than long, protruding ventrally one-third depth of rest of urosome. Caudal rami length 1⅓ times width. Inner caudal seta reduced.

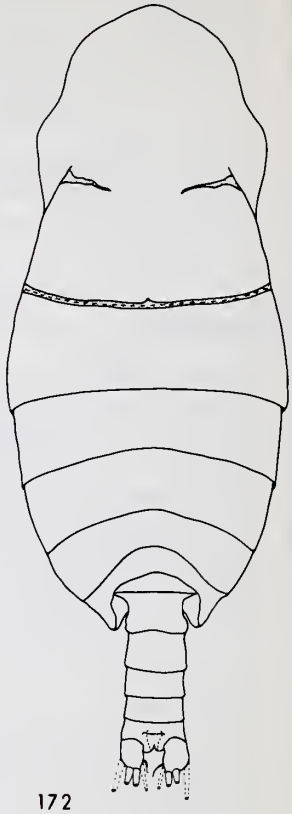
A1 terminal segments missing on all described specimens. Segments 20-25 missing on specimens examined; armature of remaining segments as Table 4.

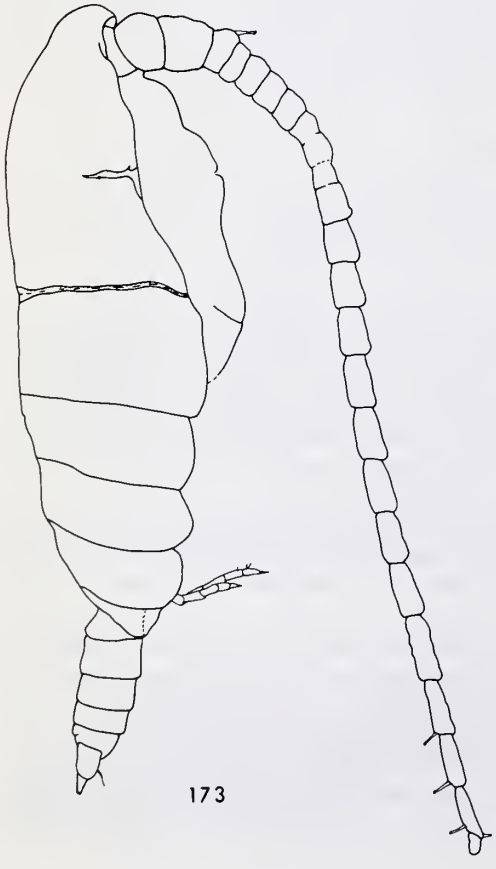
Mn B2 apparently with 2 inner setae. Blade (Fig. 171) with large, sharp, slightly curved ventral tooth followed by 2 large and 1 slender tricuspids, a shorter bicuspid, 3 slender teeth, and a dorsal seta.

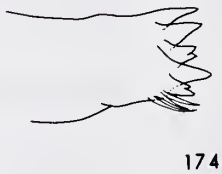
Mx1 gnathobase with 1 proximal posterior seta, nearly as large as smallest strong marginal setae; proximal anterior seta also relatively large; distal

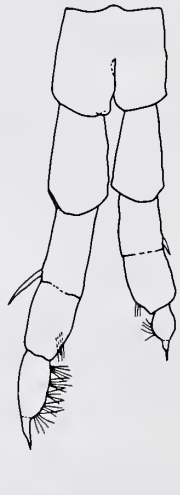






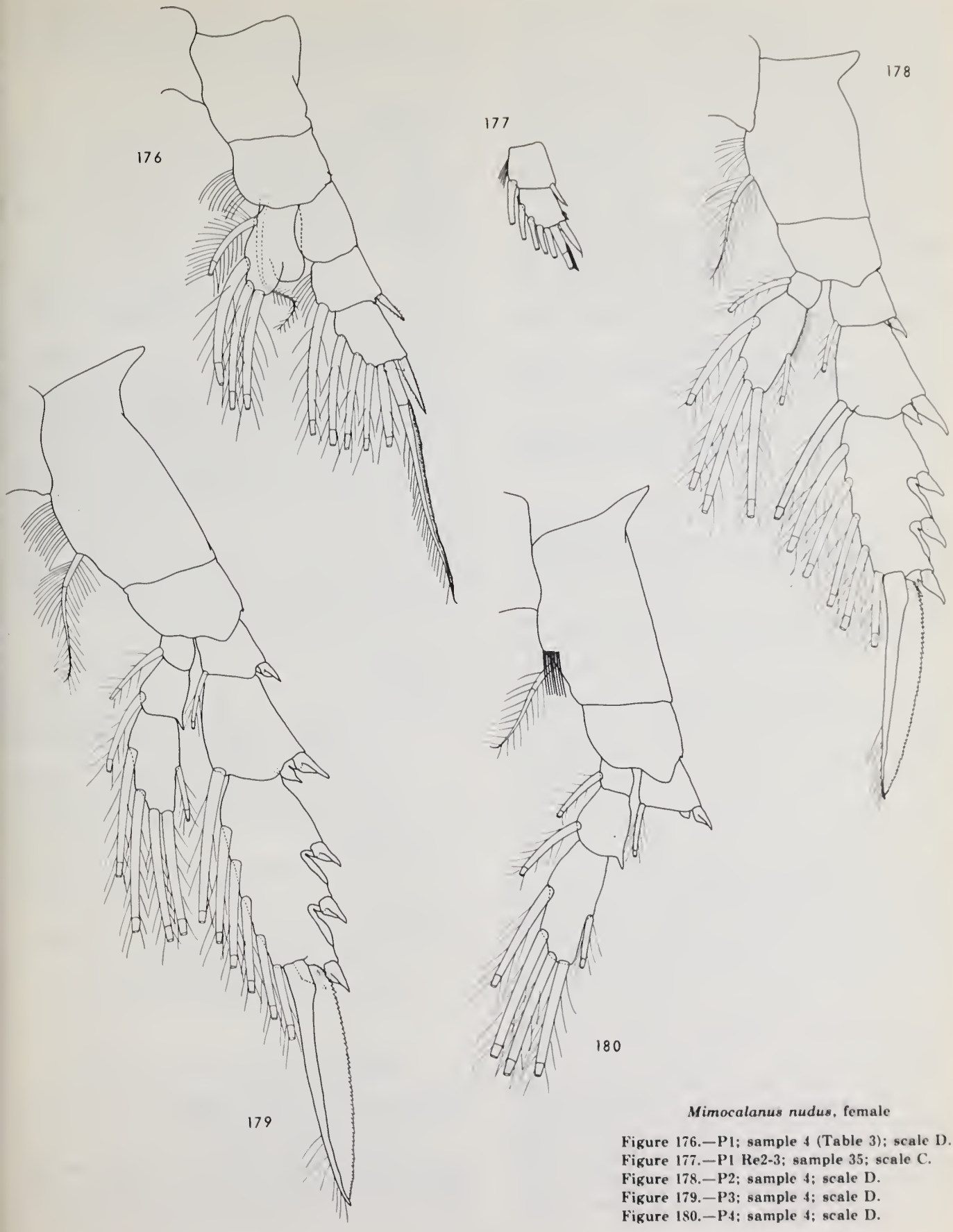






Mimocalanus nudus

Figure 169.—Female, habitus, dorsal view; sample 36 (Table 3); scale A.
Figure 170.—Female, habitus, lateral view; sample 36; scale A.
Figure 171.—Female, Mn blade; sample 35; scale D.
Figure 172.—Male, habitus, dorsal view; sample 36; scale A.
Figure 173.—Male, habitus, lateral view; sample 36; scale A.
Figure 174.—Male, Mn blade; sample 36; scale H.
Figure 175.—Male, P5; sample 36; scale D.



Mimocalanus nudus, female

Figure 176.—P1; sample 4 (Table 3); scale D.
Figure 177.—P1 Re2-3; sample 35; scale C.
Figure 178.—P2; sample 4; scale D.
Figure 179.—P3; sample 4; scale D.
Figure 180.—P4; sample 4; scale D.

anterior seta reaching beyond margin. Proximal part of Ri with 3 proximal and 3 distal setae; Ri terminal segment with 7 setae.

Mxp B1 anterior surface with midlength cluster of many thin spinules and distal series of short thin setules; distal knob with 3 setae and short truncate process. B2 proximal anterior surface with short longitudinal row of short spinules of decreasing size distally. Ri2-5 with nude inner and terminal setae. Ri4-5 outer setae moderately long, with long plumes on each side.

P1 (Figs. 176, 177) B2 and Re1 outer distal edge with few small teeth. Main body of Re2 outer spine not reaching beyond two-thirds length of Re3; some spines with a threadlike terminal part. Re3 outer spine relatively wide. Ri outer lobe large, rhomboidal.

P2 (Fig. 178) Re1 outer spine about two-thirds size of Re3 outer spines. Re3 spiniform distal edge nearly equaling size of outer distal spine.

P3 (Fig. 179) B2 outer distal edge with 2-3 sharp teeth. Re1 outer spine smaller than Re2-3 outer spines. Re3 spiniform distal edge as large as outer distal spine.

P4 (Fig. 180) B1 posterior surface with inner transverse row of very thin setules. B2 distal outer edge with dull tooth. Re outer spines relatively small; Re1 outer spine smallest. Re3 outer spines not serrate. Re3 spiniform distal edge as large as outer distal spine.

Re terminal seta with following number of teeth: P2 (52-65); P3 (56-67); P4 (ca. 61).

Male.—Length 2.50 mm (Figs. 172, 173). Prosome in dorsal view robust ovoid; anterior irregular, with slight forward protrusion. In lateral view with irregular, fairly abrupt forward slope. Prosome length 3½ times urosome. Caudal rami length 1½ times width.

A1 exceeding caudal rami by 2 segments. VIII-2s, 1e; XI-1s, 1e; left segments 17-25 missing; remainder as Table 4.

Mn blade (Fig. 174) relatively complex; 5 strong ventral teeth, 3 dorsal setiform processes.

Mx1 gnathobase reduced to 2-3 short, narrow teeth; cluster of spinules on distal anterior surface.

Mxp B1 distal lobe with 3 unequal setae. B2 with 2 small followed by 1 large midlength setae. Ri4-5 outer setae reduced or absent.

P1 Re2 outer spine length as on female; Re3 outer spine narrower than on female.

P2 Re1 outer spine as on female.

P5 (Fig. 175) reaching middle of urosome segment 3. Left B1 reaching just beyond right B1; left B2 reaching one-third length of right Re1. Left leg longer than right by more than length of Re3. Left Re longer than right. Order of length, longest to shortest, of Re segments: left 1, 2, 3; right 1 = 2, 3. Right Re3 small. Each Re1 with flat seta on outer distal edge, left 2 times length of right. Re1-2 nearly fused left and right. Inner edge of left and right Re2-3 with long hairs, those of left Re3 in tufts. Each Re with short bladelike terminal process.

Remarks

Farran (1908) reported only one female in the original description; however, at least one other specimen was taken in that survey and labeled *Mimocalanus nudus* by Farran; this second specimen was examined during the present study (sample 4, Table 3). Farran separated *M. nudus* from *M. cultrifer* essentially by size, but failed to note especially the differences in armature of the swimming legs. Farran and Vervoort (1951b) illustrated P2 Ri2 with 1 outer seta.

Brodsky (1950) first reported the distinctive sclerotization on Ce and used this characteristic to define a North Pacific species, *M. distinctocephalus.* In the present study, this sclerotization was found to be more or less developed on all *Mimocalanus* species. Brodsky referred to this feature as a "band of pigment"; however, it appeared in the present study not to be pigmented. Brodsky (fig. 56, N1) illustrated P1 Ri with 3 inner setae; this is considered in the present study as an error, or an abnormality. Brodsky's (fig. 56, N2) illustration of P2 Ri2 shows 1 outer seta. No differences were found between North Pacific "*M. distinctocephalus*" and Farran's *M. nudus*, and the two forms are considered conspecific.

Distribution

Pacific Ocean
- North: Brodsky (1950, 1957), 200-4,000 m. —Minoda (1971), 170-2,000 m.
- Northeast: von Vaupel-Klein (1970), 0-1,200 m. —Present study, 700-1,500 m.
- Northwest: Brodsky (1950, 1952a, 1955, 1957), 0-8,500 m.

Indian Ocean
- West: Grice and Hulsemann (1967), 1,000-2,000 m.

Atlantic Ocean
- Northeast: Farran (1908), 1,440 m. —Present study, 720-900 m.
- East: Roe (1972a, b), 700-960 m.
- Caribbean Sea: Park (1970), 980-2,800 m.

3. *Mimocalanus major* Sars, 1920

Mimocalanus major Sars, 1920, p. 4. —Sars, 1924, 1925, p. 35-36, pl. 10, fig. 1-16.

TYPE SPECIMEN: Holotype, female (4.20 mm), on slide, OSLO.
TYPE LOCALITY: Central North Atlantic, 0-3,000 m.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta; P3-P4 Ri3 with 1 outer seta.

Female.—Length of only known specimen 4.20 mm. Prosome in dorsal view slender ovoid; head somewhat truncate. In lateral view with abrupt forward slope. Th4 and Th5 separate. Prosome length nearly 5 times urosome. Caudal rami about as long as wide.

Labrum with 3 large protuberances on midventral surface.

A1 segment 1 with 2 strong setae.

Male.—Unknown.

Remarks

Sars' (1924, 1925) description is thorough, but should be confirmed with additional specimens. Sars states that Ce and Th1 are fused. He did not describe an inner transverse row of setules on P4 B1, present on most *Mimocalanus* species. The 2 strong setae on A1 segment 1 are unusual, and perhaps there is a third strong seta.

Distribution

Known only from the original record, Central North Atlantic, 0-3,000 m.

4. *Mimocalanus inflatus* Davis, 1949

Mimocalanus inflatus Davis, 1949, p. 24. —Grice and Hulsemann, 1965, p. 227, fig. 5o-w. —?Grice and Hulsemann, 1967, p. 20, fig. 16-18.

TYPE SPECIMEN: Unknown.
TYPE LOCALITY: Northeast Pacific, 1,900-2,900 m.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta; P3-P4 Ri3 with 1 outer seta.

Female.—Length (1.76?-) 2.3-2.4 mm. Known for only two specimens (Davis, 1949; Grice and Hulsemann, 1965).

Male.—Unknown.

Remarks

Grice and Hulsemann (1967) reported two small specimens (1.76-2.01 mm) but the swimming feet were lacking, and they questioned this identification, which could be of *M. ovalis* or other species.

Davis (1949) did not illustrate this species, and it is not certain whether his specimen had P1-P4 armature as described above (taken from Grice and Hulsemann, 1965). The only characteristic which set the two specimens apart from other *Mimocalanus* species was the inflated P2-P4 Ri2.

Distribution

Pacific Ocean
  Northeast: Davis (1949), 1,900-2,900 m.
Indian Ocean
  West: ?Grice and Hulsemann (1967), 1,000-2,000 m.
Atlantic Ocean
  East: Grice and Hulsemann (1965), 1,900-3,000 m.

(5. *Mimocalanus distinctocephalus* Brodsky, 1950)

See *Mimocalanus nudus* Farran, 1908.

6. *Mimocalanus ovalis* (Grice and Hulsemann, 1965), new combination

(Figure 160)

Spinocalanus ovalis Grice and Hulsemann, 1965, p. 229, fig. 7b-f.
?*Spinocalanus ventriosus* Grice and Hulsemann, 1967, p. 21-22, fig. 32-34.

TYPE SPECIMEN: Holotype, female, BM 1965.4.20.3.
TYPE LOCALITY: Northeast Atlantic, 1,900-5,000 m.
MATERIAL STUDIED: 2 paratypes, female (1.32 mm), sample 48 (Table 3). Also the holotype of *Spinocalanus ventriosus*, female (damaged), sample 43.

Description

P1 Ri with 2 inner setae; P2 Ri2 with no outer seta; P3-P4 Ri3 with 1 outer seta.

Female.—Length 1.16-1.52 mm. Prosome in dorsal view robust ovoid; head broadly rounded. In lateral view with abrupt forward slope. Th4 and Th5 separate; Th5 lateral corners reaching midgenital segment. Prosome length 3½ times urosome. Genital segment slightly longer than wide, protruding ventrally one-half depth of rest of urosome. Caudal rami length about equaling width.

A1 reaching only to midgenital segment; segment 2 length about 1½ times segment 1; segments 8-9 completely fused; terminal segments (Fig. 160) relatively wide, short. Segments 8 through 24 with 1-2 rows of minute denticles on ventral and dorsal surface, not noticed on any other Spinocalanidae. Segment 1 damaged; armature of remaining segments as Table 4.

Mn B2 with 3 inner setae (Grice and Hulsemann, 1965, fig. 7c).

Mxp B1 with row of thin setules on midanterior surface, and 4 clusters of thin spinules on outer posterior surface; distal lobe anterior surface covered with setules; 1 relatively long and 1 small distal setae, and 1 long truncate distal process. B2 with longitudinal row of stiff hairs; 2 midlength setae, followed by more distal seta and 2 distal setae. Ri segments rhomboidal; inner subterminal setae short (some probably missing from specimens examined), but terminal seta thick, not expanded, probably very long (broken). Ri4-5 outer setae relatively thick and long; each side with long plumes.

P1 B2 with small outer seta and long inner anterior seta, as in other Spinocalanidae. B2 inner edge without hairs; Re1 nude. Ri outer lobe reduced to small lamella.

P2-P3 B1 inner edge with hairs and 1 seta; outer anterior surface with few setules. Specimens examined lacked P2-P4 Re2-3.

Male.—Unknown.

Remarks

Mimocalanus ovalis has some characteristics of *Spinocalanus* species: relative lengths of A1 segments 1-2 and complete fusion of segments 8-9, and armament and spacing of setae on Mxp B2. However, the lack of outer distal spine on P1 Re1, lack of surface spines on swimming legs, number of setae on Ri of swimming legs, 3 inner setae on Mn B2, form of Mxp Ri4-5 outer setae, and prolonged Th5 would indicate placement with *Mimocalanus* species. Specimens with complete Re of swimming legs should be examined.

Grice and Hulsemann (1967) briefly described females of a new species *Spinocalanus ventriosus*. Except for a slight knoblike protrusion at the tip of Th5, their description is consistent with that of *Mimocalanus ovalis*. The knoblike protrusion could be an artifact, caused by a contraction of the body walls at that point, as it appeared to be in the holotype examined in the present study. The holotype was lacking A1 distal segments, P1-P4 Re2-3, P2 Ri2, and P3-P4 Ri2-3. P1 Re1, P1 Ri, P2-P3 B1, A1 segments 1-2 and 8-9, and Mxp B2 as in *M. ovalis*. There was no indication of an outer spine on P1 Re1; usually a socket, or at least a torn thread, can be seen if the spine is detached. The holotype lacked the swimming leg segments that would have surface spines in *Spinocalanus*, so that placement of *S. ventriosus* with *Mimocalanus ovalis* may still be questionable.

Distribution

Indian Ocean
West: Grice and Hulsemann (1967), 1,000-4,000 m.

Atlantic Ocean
Northeast: Grice and Hulsemann (1965), 1,900-5,000 m.

(7. *Mimocalanus* species Grice and Hulsemann, 1967)

See *Mimocalanus crassus* Park, 1970.

8. *Mimocalanus crassus* Park, 1970

(Figures 161, 181-191)

Mimocalanus species Grice and Hulsemann, 1967, p. 21, fig. 19-25.
Mimocalanus crassus Park, 1970, p. 478-481, fig. 1-12.

TYPE SPECIMEN: Holotype, female (0.95 mm), USNM 123771.
TYPE LOCALITY: Caribbean Sea, 487-2,800 m.
MATERIAL STUDIED: Holotype, female (0.95 mm), sample 55 (Table 3); 1 female (1.08 mm), sample A5 (Table 1); 1 female (1.0 mm), sample A6; 1 female (1.20 mm), sample A23; 2 males (1.27, 1.36 mm), sample A29; 3 females (1.16, 1.20, 1.24 mm) and 1 male (1.24 mm), sample A31; 3 males (1.08 mm), sample A32; 1 female (1.20 mm), sample A33; 1 female (1.20 mm), sample A36; 2 females (1.16, 1.24 mm), sample A45; 3 females (1.20, 1.26, 1.27 mm) and 1 male (1.22 mm), sample A48; 23 females (1.08-1.25 mm, mean = 1.12 mm) and 1 male (1.04 mm), sample A51.

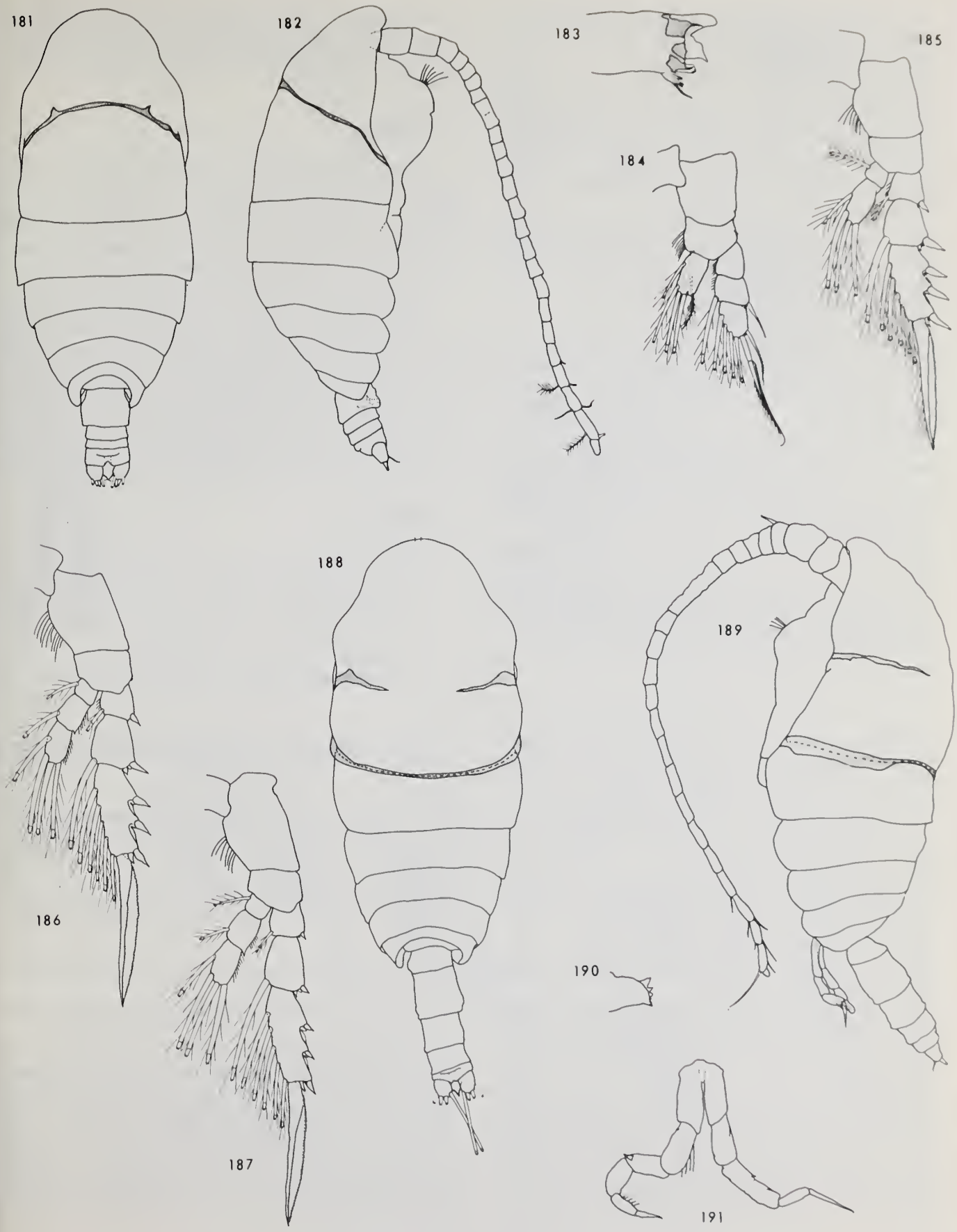
Description

Right P1 Ri with 2 inner setae; *left* P1 Ri with 1 inner seta, distal. P2 Ri2 with no outer seta. P3-P4 Ri3 with no outer seta. P2-P4 B1 without inner seta.

Female.—Length 0.95-1.27 mm (Figs. 181, 182). Prosome in dorsal view robust ovoid; head rounded. In lateral view with abrupt forward slope. Th4 and Th5 separate. Prosome length 4⅓ times urosome. Genital segment length three-fourths times width, protruding ventrally one-fourth depth of rest of urosome. Caudal rami length slightly greater than width.

Mimocalanus crassus

Figure 181.—Female, habitus, dorsal view; scale B.
Figure 182.—Female, habitus, lateral view; scale B.
Figure 183.—Female, Mn blade; scale D.
Figure 184.—Female, P1; scale D.
Figure 185.—Female, P2; scale D.
Figure 186.—Female, P3; scale D.
Figure 187.—Female, P4; scale D.
Figure 188.—Male, habitus, dorsal view; scale B.
Figure 189.—Male, habitus, lateral view; scale B.
Figure 190.—Male, Mn blade; scale D.
Figure 191.—Male, P5; scale D.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A1 exceeding caudal rami by about 2 segments; terminal segments (Fig. 161) of moderate length and width. Armature as Table 4.

A2 Re2-3 not fused, otherwise as shown by Park (1970, fig. 3).

Mn B1 with 3 inner setae. Mn blade (Fig. 183) relatively large; large rounded ventral tooth, 1 broad irregular midlength tooth followed by rounded bicuspid, and dorsal projection with 2 sharp, narrow teeth, 1 tricuspid, and dorsal seta.

Mx1 as shown by Park (1970, fig. 5); gnathobase with 4 proximal posterior setae and short spinelike distal anterior seta. B2 with 7 inner setae. Proximal part of Ri with 7 proximal and 7 distal setae; Ri terminal segment with 9 setae.

Mxp as shown by Park (1970, fig. 7); B1 with spinules midlength on inner edge; distal lobe with short spinules, 3 setae, and short truncate process. B2 with short longitudinal row of spinules on proximal inner edge. Ri4-5 outer setae lightly plumose, thin and relatively short.

P1 (Fig. 184) Re2 outer distal spine reaching beyond base of Re3 outer distal spine. P1 Ri with moderate lobe; setae asymmetrical as described above.

P2 (Fig. 185) Re1 outer distal spine smaller than outer spines of Re2-3.

P3 (Fig. 186) B2 outer distal edge with 2-3 small teeth.

P4 (Fig. 187) B1 inner margin with hairs, without inner seta and without transverse row of setules. Re outer spines smaller than on P2-P3.

Re terminal seta with following number of teeth: P2 (55-63); P3 (ca. 55); P4 (ca. 48).

Male.—Length 0.78-1.36 mm (Figs. 188, 189). Prosome in dorsal view robust ovoid; anterior irregular, head rounded. In lateral view with irregular, abrupt forward slope. Prosome length 2¾ times urosome. Caudal rami length equaling width.

A1 reaching middle of urosome segment 2. A1 segments 8-9 relatively elongate. VIII-2s, 1e; XI-2s, 1e; remainder as Table 4.

Mn blade (Fig. 190) with 6 small teeth, decreasing in size dorsally, and minute dorsal seta.

Mx1 gnathobase reduced to 1 or 2 teeth.

P1 as on female, Ri asymmetrical.

P2 as on female, except Re3 outer spines sharply curved near tip.

P3-P4 missing Re2-3 on specimens examined; remainder as on female, except B2 outer distal edge without teeth, and Ri2 outer spiniform process reduced.

P5 (Fig. 191) nearly reaching distal edge of urosome segment 3. Left B1 reaching one-fourth length of right B2; left B2 reaching one-half length of right Re1. Left and right legs about equal length. Right Re, including terminal blade, slightly longer than left. Order of length, longest to shortest, of Re segments: left 2, 1, 3; right 1 = 2 = 3. Each Re1 with short flat seta on outer distal edge, left wider than right. Right Re1-2 nearly fused. Inner edge of left B2 and Re3 with long hairs. Each Re with moderate bladelike terminal process, longer on right.

Remarks

Park (1970) indicated *M. crassus* P1 Ri with "3 or 4 setae"; his illustration (fig. 8) shows right P1 with 3 setae, as does the illustration of male right P1 by Grice and Hulsemann (1967, fig. 24). Park's illustration (fig. 11) of male left P1 shows 3 setae, in agreement with specimens examined in the present study. P1 of holotype had been removed prior to deposit.

Mimocalanus crassus is the only Spinocalanidae with asymmetrical P1. *Mimocalanus crassus* is also the only Spinocalanidae with no outer seta on P3-P4 Ri3; no inner seta on P2-P4 B1; Mx1 B2 with 7 inner setae, Ri proximal part with 7 and 7 setae, and Ri terminal segment with 9 setae. *Mimocalanus crassus* is the only *Mimocalanus* species with short, lightly plumose outer setae on Mxp Ri4-5, and without inner transverse row of setules on P4 B1 (see *M. major*).

Distribution

Arctic Ocean
  Canadian Basin: Present study, 400-2,500 m.
Indian Ocean
  West: Grice and Hulsemann (1967), 2,000-3,000 m.
Atlantic Ocean
  Caribbean Sea: Park (1970), 487-2,800 m.

9. *Mimocalanus sulcifrons* Wheeler, 1970

(Figures 162, 192-215)

Mimocalanus nudus. —Grice and Hulsemann, 1965, p. 227, fig. 6a-l. Not *M. nudus* Farran, 1908.

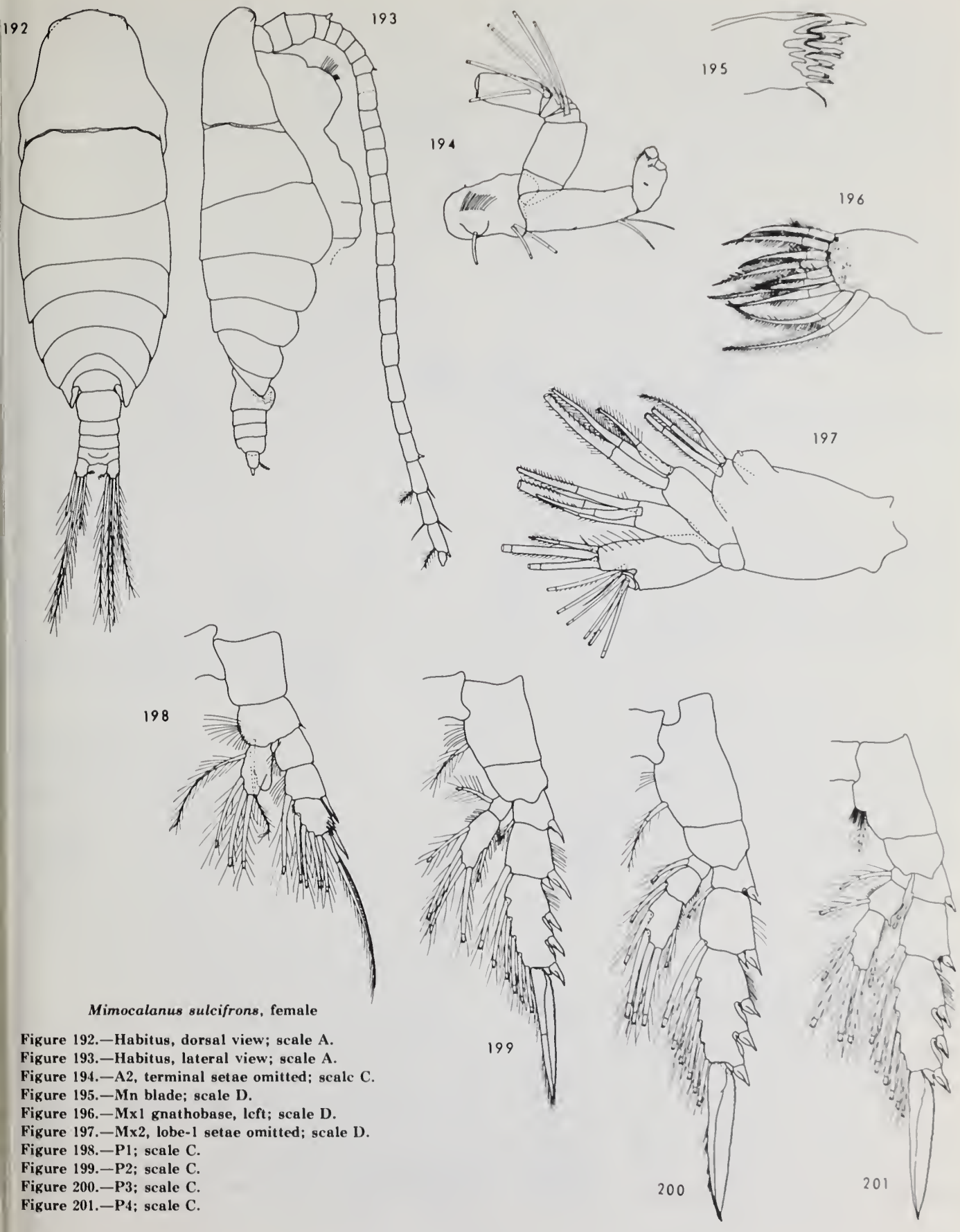
Mimocalanus sulcifrons Wheeler, 1970, p. 7-9, fig. 5-20.

Mimocalanus distinctocephalus. —Vidal, 1971, p. 17-18, fig. 60-63. Not *M. distinctocephalus* Brodsky, 1950.

TYPE SPECIMEN: Holotype, male (1.90 mm), USNM 122646.

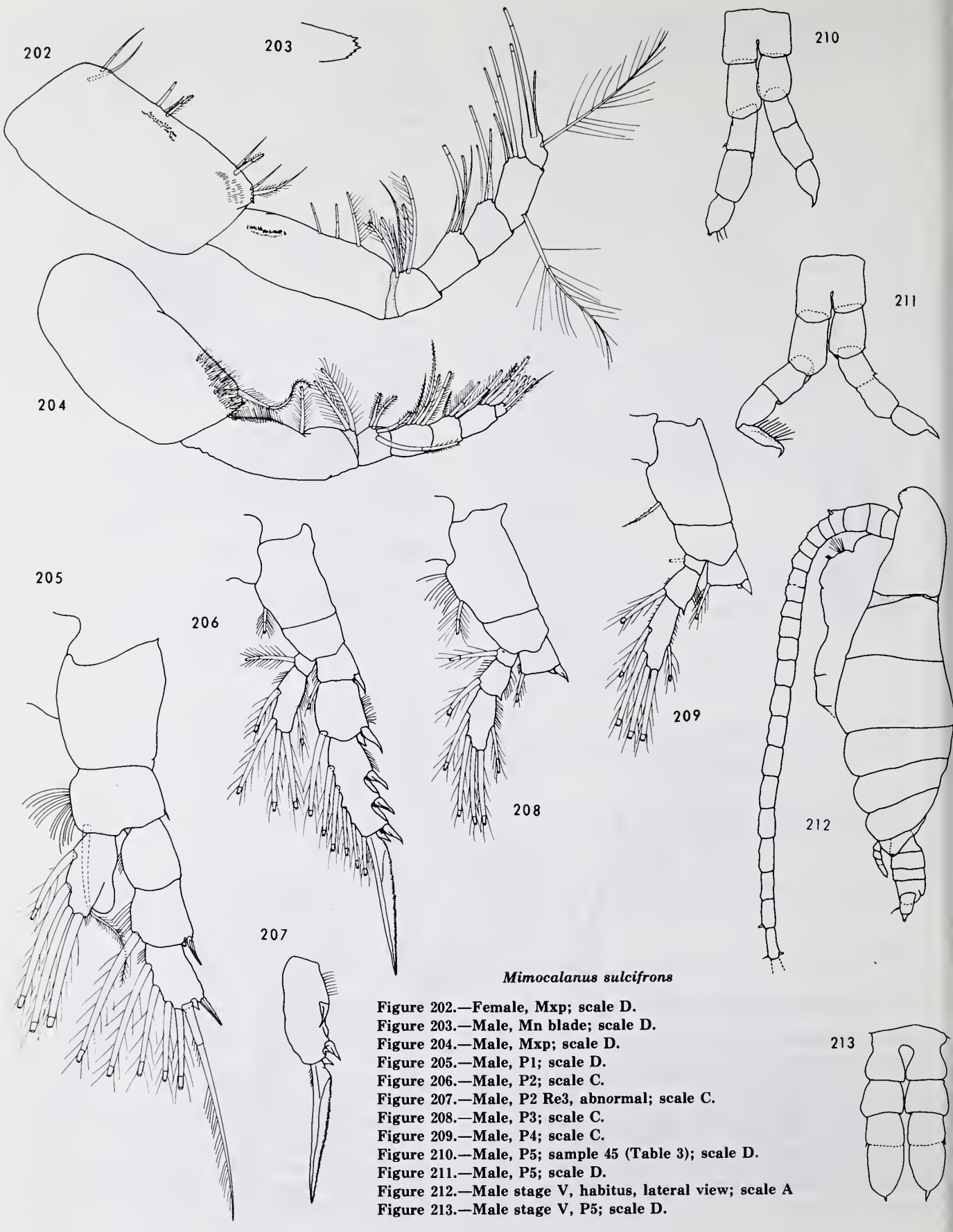
TYPE LOCALITY: Western North Atlantic, 2,000-4,000 m.

MATERIAL STUDIED: Holotype, male (1.90 mm), sample 45 (Table 3); 3 females (2.20, 2.30, 2.30 mm), sample A26 (Table 1); 3 females (2.24, 2.28, 2.32 mm), sample A48; 4 females (2.05-2.40 mm, mean = 2.23 mm), 4 males (2.15-2.60 mm, mean = 2.37 mm), and 1 stage V male (2.08 mm), sample A50; 4 females (2.17-2.30 mm, mean = 2.24 mm) and 1 stage V male (2.04 mm), sample A51; 1 female (2.24 mm), sample A52.



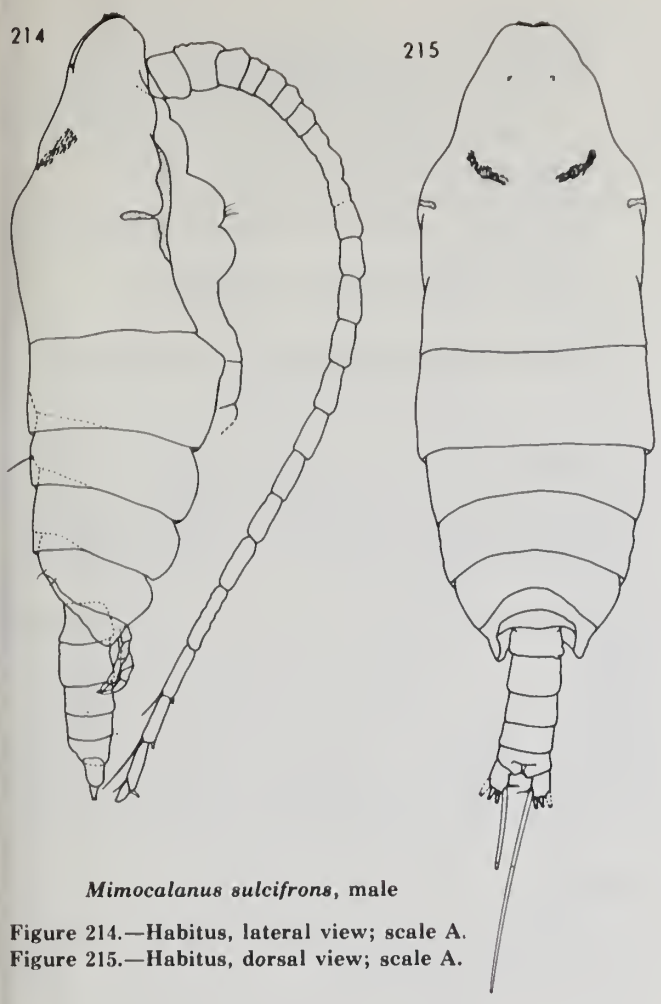
Mimocalanus sulcifrons, female

Figure 192.—Habitus, dorsal view; scale A.
Figure 193.—Habitus, lateral view; scale A.
Figure 194.—A2, terminal setae omitted; scalc C.
Figure 195.—Mn blade; scale D.
Figure 196.—Mx1 gnathobase, lcft; scale D.
Figure 197.—Mx2, lobe-1 setae omitted; scale D.
Figure 198.—P1; scale C.
Figure 199.—P2; scale C.
Figure 200.—P3; scale C.
Figure 201.—P4; scale C.



Mimocalanus sulcifrons

Figure 202.—Female, Mxp; scale D.
Figure 203.—Male, Mn blade; scale D.
Figure 204.—Male, Mxp; scale D.
Figure 205.—Male, P1; scale D.
Figure 206.—Male, P2; scale C.
Figure 207.—Male, P2 Re3, abnormal; scale C.
Figure 208.—Male, P3; scale C.
Figure 209.—Male, P4; scale C.
Figure 210.—Male, P5; sample 45 (Table 3); scale D.
Figure 211.—Male, P5; scale D.
Figure 212.—Male stage V, habitus, lateral view; scale A
Figure 213.—Male stage V, P5; scale D.



Mimocalanus sulcifrons, male

Figure 214.—Habitus, lateral view; scale A.
Figure 215.—Habitus, dorsal view; scale A.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta; P3-P4 Ri3 with 1 outer seta.

Female.—Length 2.05-2.40 mm (Figs. 192, 193). Prosome in dorsal view ovoid; head broadly rounded, with slight anterior protrusion and 2 indistinct dorsolateral swellings. In lateral view with abrupt forward slope. Th4 and Th5 separate. Prosome length 4½ times urosome. Genital segment length two-thirds times width, protruding ventrally one-third depth of rest of urosome. Caudal rami length 1½ times width. Inner caudal seta reduced.

A1 exceeding caudal rami by 4 segments; terminal segments (Fig. 162) relatively wide, large. Armature as Table 4.

Mn B2 with 3 inner setae. Mn blade (Fig. 195) with 1 long ventral tooth, followed by 4 bi- or tricuspids of decreasing length, slender dorsal bicuspid, and dorsal seta.

Mx1 gnathobase (Fig. 196) without proximal posterior setae; proximal anterior seta thin and finely plumose; distal anterior seta on left only, reaching beyond margin. Proximal part of Ri with 3 proximal and 3 distal setae.

Mxp (Fig. 202) B1 inner anterior surface with midlength cluster of few denticles and distal series of short thin setules; distal knob with 4 setae and short truncate process. B2 proximal anterior surface with short longitudinal row of short, relatively thick spines of irregular length, paralleled by very short, thin spinules. Ri2-5 inner setae and terminal seta, nude. Ri4-5 outer setae moderately long, with very long plumes on each side.

P1 (Fig. 198) B2 and Re1 outer distal edge with 2-3 small teeth. Main body of Re2 outer spine just reaching base of Re3 outer spine; Re3 outer spine narrow. Ri outer lobe moderate.

P2 (Fig. 199) B2 outer distal edge with 3-4 small blunt teeth. Re1 outer spine equaling size of Re3 outer spines. Re3 spiniform distal edge much smaller than outer distal spine.

P3 (Fig. 200) similar to P2.

P4 (Fig. 201) B1 posterior surface with inner transverse row of very thin, uniform setules. Re3 outer spines finely serrate.

Re terminal seta with following number of teeth: P2 (79-90); P3 (80-89); P4 (73-83).

Male.—Length 1.90-2.60 mm (Figs. 214, 215). Prosome in dorsal view elongate ovoid; anterior narrow, with anterior depression lined with short hairs. Mid-Ce with dorsolateral oblique rows of flat, prominent, fragile spines. Prosome in lateral view with irregular, fairly gentle, forward slope. Prosome length 3¾ times urosome. Caudal rami length 1¼ times width.

A1 exceeding caudal rami by 1 segment. VIII-2s, 2e; XI-2s, 1e; remainder as Table 4.

Mn blade (Fig. 203) reduced to 6-7 subequal teeth.

Mx1 gnathobase with 6-7 toothlike setae. Inner lobes-1-2 reduced (as Wheeler, 1970, fig. 14); outer lobe-1 with very long, fragile, plumose setae, 2 of which reach urosome; Re as on female.

Mx2 overall appearance as illustrated by Wheeler (1970, fig. 15); lobe-1 with 3-4 reduced setae, lobe-2 with 3 longer setae; lobe-3-4 with 3 still longer setae; lobe-5 with 2 long setae. Lobe-6 and Ri1-2 with 1 coarsely plumose seta, as long as Mx2; Ri3 with 3 long setae.

Mxp (Fig. 204) B1 distal lobe with dense patch of setules; B2 with dense longitudinal row of stiff hairs; several setae apparently missing on specimens examined. Ri1-5 inner setae and terminal seta plumose; outer setae reduced or absent.

P1 (Fig. 205) Re2 outer spine reaching about midlength Re3; Re2-3 outer spines finely serrate.

P2 (Fig. 206) Re1 outer spine nearly as long as Re3 outer spines. Re terminal seta with 69-76 teeth.

P3 (Fig. 208)-P4 (Fig. 209) missing Re2-3 on specimens examined; P4 B1 inner seta reaching middle of B2.

P5 (Figs. 210, 211) reaching distal edge of urosome

segment 3. Left B1 reaching one-fifth to one-fourth length of right B2; left B2 reaching one-half length of right Re1. Left leg longer than right by length of Re3. Left Re longer than right. Order of length, longest to shortest, of Re segments: left 2, 1, 3; right 1 = 2 = 3. Right Re3 not small. Each Re1 probably with short flat seta on outer distal edge. Right Re1-2 more or less fused. Inner edge of left Re3 with long hairs. Each Re with short bladelike terminal process.

Male stage V.—Length 2.04-2.08 mm (Fig. 212). Ce sclerotization about as on adult female. P5 (Fig. 213) uniramus, symmetrical. Re incompletely 2-segmented; Re1 with outer distal seta; Re2 with short bladelike terminal process.

Remarks

Mimocalanus nudus and *M. sulcifrons* females are similar, while the males are more distinct. Both species are found in the North Atlantic, but *M. sulcifrons* has not been found in the Pacific, nor *M. nudus* in the Arctic. The present study considers the larger male Arctic *Mimocalanus* species to be conspecific with *M. sulcifrons*; therefore, the larger Arctic female is most likely also *M. sulcifrons*, described for the first time. The large North Pacific female *Mimocalanus* species is considered identical to *M. nudus*; the corresponding Pacific male is, therefore, most likely to be male *M. nudus*, described for the first time.

Wheeler (1970) found one male specimen on which he based the description of *M. sulcifrons*. His description of the "horn-shaped esthetes" was of the esthete bases only. Th4 and Th5 of the holotype are separate, as on other male Spinocalanidae. Wheeler stated that P1 Ri had "1 subterminal, and 2 terminal setae," however his illustration (fig. 17) correctly shows a total of 4 setae. The anterior depression was much more pronounced on the holotype, and the holotype did not possess the conspicuous dorsolateral spines of the Arctic males. However, the other characteristics of the holotype of *M. sulcifrons* were consistent with those of the Arctic males. Perhaps the "sulcus" and the dorsolateral spines are characteristics of age of the adult male (see *Spinocalanus dorsispinosus* Brodsky, 1950).

Grice and Hulsemann (1965) reported one male *M. nudus* from the northeast Atlantic. Their description is generally consistent with that of male *M. sulcifrons*. The illustration of dorsal view (fig. 6a) clearly shows a depressed anterior, while male *M. nudus* has a protruding anterior margin, and is more robust.

Distribution

Johnson (1963a), Minoda (1967), Hughes (1968), and Dunbar and Harding (1968) reported *M. distinctocephalus* from the Arctic; these records will be considered as *M. sulcifrons* in the present study.

Arctic Ocean
- Eurasian Basin: Minoda (1967), 0-520 m.
- Canadian Basin: Johnson (1963a), 0-2,000 m. —Hughes (1968), 80-90 m. —Dunbar and Harding (1968), 0-2,000 m. —Vidal (1971). — Present study, 100-2,500 m.

Atlantic Ocean
- Northeast: Grice and Hulsemann (1965), 2,000-4,000 m.
- West: Wheeler (1970), 2,000-4,000 m.

10. *Mimocalanus heronae*, new species

(Figures 163, 216-223)

Mimocalanus cultrifer. —Tanaka, 1956, p. 387-389, fig. 13. Not *M. cultrifer* Farran, 1908.

Mimocalanus distinctocephalus. —Boucher and de Bovée, 1970, p. 527-534, fig. 1-2. Not *M. distinctocephalus* Brodsky, 1950.

TYPE SPECIMEN: Holotype, female (1.23 mm), USNM 142702.

TYPE LOCALITY: Central and Northeast Pacific, 0-1,000 m.

MATERIAL STUDIED: Holotype, female (1.23 mm), sample 31 (Table 3); 2 paratypes, females (1.25, 1.27 mm), sample 32, SIO XVIII-779; 1 paratype, female (1.28 mm), sample 32, USNM 142703.

Description

P1 Ri with 2 inner setae; P2 Ri2 with 1 outer seta; P3-P4 Ri3 with 1 outer seta.

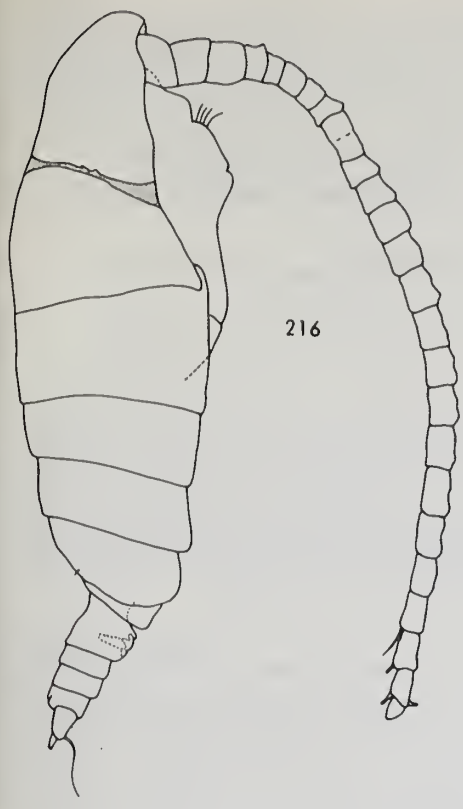
Female.—Length 1.23-1.95 mm (Figs. 216, 217). Prosome in dorsal view slender ovoid; head rounded. In lateral view with irregular, fairly abrupt forward slope. Th4 and Th5 partly fused. Prosome length nearly 4 times urosome. Genital segment slightly wider than long, protruding ventrally one-third depth of rest of urosome. Caudal rami length slightly greater than width. Inner caudal seta small, not reduced.

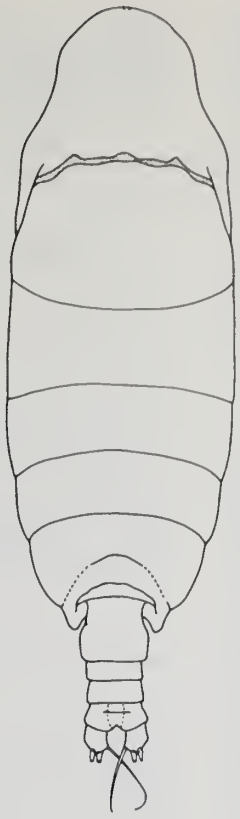
A1 exceeding caudal rami by nearly 1 segment; terminal segments (Fig. 163) relatively wide. Segment 9 partly fused with segment 10. Armature as Table 4.

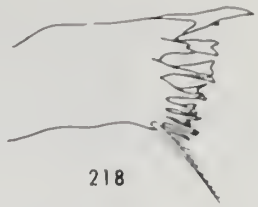
Mn B2 with 2 short inner setae; proximal seta thick, nude, distal seta plumose. Blade (Fig. 218) with large ventral bicuspid, followed by 4 bi- or tricuspids of decreasing length, 2 narrow bicuspids, 1 thin sharp process, and dorsal seta.

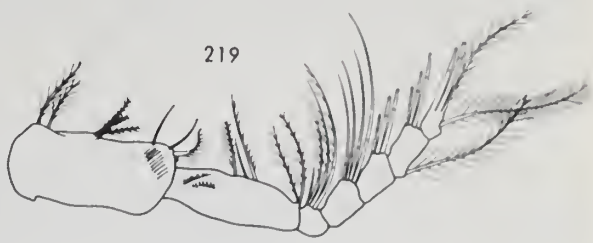
Mx1 gnathobase without proximal posterior setae; left and right with short distal anterior seta. Proximal part of Ri with 3 proximal and 3 distal setae.

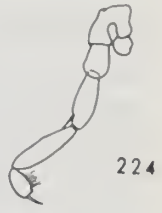
Mxp (Fig. 219) B1 distal knob with long anterior surface hairs, 3 subequal setae, and short truncate process. B2 anterior surface with proximal row of short hairs and row of denticles. Ri2-5 inner setae nude; Ri4-5 outer setae moderately long with long plumes each side; terminal seta plumose.











Mimocalanus heronae, female

Figure 216.—Habitus, lateral view; sample 31 (Table 3); scale B.
Figure 217.—Habitus, dorsal view; sample 31; scale B.
Figure 218.—Mn blade; sample 31; scale G.
Figure 219.—Mxp; sample 31; scale D.
Figure 220.—P1; sample 31; scale D.
Figure 221.—P2; sample 31; scale D.
Figure 222.—P3; sample 31; scale D.
Figure 223.—P4; sample 31; scale D.

Teneriforma naso, male

Figure 224.—P5; sample 42; scale D.

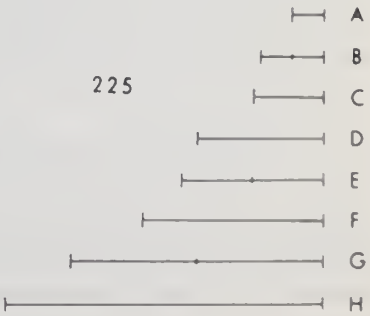


Figure 225.—Scales A-H, 0.1 mm.

P1 (Fig. 220) Re1 outer distal edge with 1-3 small teeth. Re2 outer spine not reaching beyond two-thirds length of Re3. Re3 outer spine narrow. Ri outer lobe moderate, with small terminal point.

P2-P4 (Figs. 221-223) variously incomplete on specimens examined in this study. P4 B1 with inner transverse row of thin, uniform setules.

Male.—Length of only known specimen 1.28 mm (Tanaka, 1956). According to Tanaka: right P5 with 4 segments, but probably Re1-2 more or less fused; Re3 relatively large (Tanaka, fig. 13i); left P5 exceeding right by Re3 and one-half length of Re2.

Remarks

Tanaka (1956) described two females and one male *M. cultrifer*; his illustration (fig. 13f) of P2 Ri2 suggests an outer seta, not possessed by *M. cultrifer*. In other respects, also, his description is consistent with that of *M. heronae*.

Boucher and de Bovée (1970) reported the first *Mimocalanus* species from the Mediterranean Sea, four females which were identified as *M. distinctocephalus*. Their description, including figures of complete P2-P4, is consistent with that of *M. heronae*, except they stated that Th4 and Th5 were separate, a characteristic that may be variable, as in some *Spinocalanus* species. They also stated that P2 Ri2 and P3-P4 Ri3 have 2 outer setae; their figure of P2 suggests 1 outer seta, and their figures of P3-P4 indicate 1 outer seta, consistent with *M. heronae*. Their Table 3 indicates 1 outer seta on P2 B2, which should instead be indicated for P1 B2. Perhaps the Mediterranean specimens reported by Grice (1971) as *M. cultrifer* are also *M. heronae* (see *M. cultrifer*).

Distribution

Minoda (1971) reported two females (1.55, 1.95 mm) said to be equivalent to Tanaka's species. These are also considered *M. heronae* in the present study.

Vervoort (1946) reported *M. cultrifer* females up to 1.91 mm, from the Indo-Pacific; it is possible that the specimens longer than 1.70 mm are *M. heronae*.

Pacific Ocean
- North: Minoda (1971), 743-1,230 m.
- Northeast: Present study, 300 m.
- Central: Present study, 0-1,000 m.
- Northwest: Tanaka (1953, 1956), 300-500 m. —Minoda (1971), 195-485 m.
- Indo-Pacific: ?Vervoort (1946), 636-900 m.

Atlantic Ocean
- Mediterranean Sea: Boucher and de Bovée (1970), 50-500 m.

Etymology: I am pleased to name this species for Gayle A. Heron, Department of Oceanography, University of Washington, Seattle, in gratitude for her unfailing friendship over nearly 20 years and in recognition of her enthusiasm and skill in the study of the Copepoda.

Genus *Teneriforma* Grice and Hulsemann, 1967

Tanyrhinus Farran, 1936.
not *Tanyrhinus* Mannerheim, 1852.

Type Species: *Teneriforma naso* (Farran, 1936).

Description

Rostrum a single long blunt cone. P1 Re1 without outer distal spine; Re1-2 together only slightly longer than Re3. *P1 Ri with 2 inner setae. P2 Ri2 with 1 outer seta. P3-P4 Ri3 with 2 outer setae. Surface of swimming leg segments without spines.* Caudal rami symmetrical, length 2-2½ times width.

Female.—Prosome in dorsal view slender ovoid; head rounded. In lateral view with very abrupt forward slope. Th5 lateral corners prolonged, reaching one-third length of genital segment. Th1-Th4 without lateral spinules. Th4 and Th5 separate. Prosome length 3-3⅓ times urosome. Genital segment protruding ventrally one-fourth to one-third depth of rest of urosome.

A1 reaching anal segment; segment 2 length about equaling segment 1; segments 8 and 9 fused.

A2 Re length about equaling Ri. *Re1 with 1 seta*; *Re2 and Re3 fused*; *Re2 with 2 setae.*

Mn B2 with 3 inner setae.

Mxp B1-2 without transverse spine-comb; B2 apparently with only 2 midlength setae, and without longitudinal row of stiff hairs or other armament. Published illustrations of Ri1-3 indicating less setae than typical for the family. Ri4-5 outer setae moderately long, plumosity unknown.

P2-P4 Re terminal seta with moderately coarse serrate outer edges; outer flange narrow.

P4 B1 posterior surface apparently without inner transverse row of hairs or setules. Inner seta present.

Male.—Prosome in dorsal view elongate ovoid; head rounded. In lateral view with very abrupt forward slope. Th5 lateral corners prolonged, as in other male Spinocalanidae; nearly reaching urosome segment 2. Ce not expanded. Ce and Th1 separate. Prosome length 3 times urosome. *Anal segment not reduced*, length two-thirds times caudal ramus.

A1 reaching to end of caudal rami; segment 2 length about equaling segment 1; segments 9 and 10 separate; segments beyond 10 not fused; right A1 missing from specimen examined; left segments 20 and 21 distinct, as in left-handed species; segment 25 not reduced.

P5 (Fig. 224) *uniramus*, left-handed, very asymmetrical. Right B2 reduced to small knob; no

right Re. Left B1 reaching midlength of right B2. Left Re 3-segmented; Re1 with short outer distal seta; Re3 inner edge with long hairs; short terminal seta. Order of length, longest to shortest, of left Re segments: 2, 1, 3.

Only a single species is known, *Teneriforma naso.*

Teneriforma naso (Farran, 1936)

(Figure 224)

Tanyrhinus naso Farran, 1936, p. 86-87, fig. 4. —Grice and Hulsemann, 1965, p. 231, fig. 8.
Teneriforma naso. —Grice and Hulsemann, 1967, p. 22, fig. 36-38. —Wheeler, 1970, p. 9-10, fig. 27-28.

TYPE SPECIMEN: Unknown.
TYPE LOCALITY: Southwest Pacific, 0-600 m.
MATERIAL STUDIED: 1 male (0.92 mm), sample 42 (Table 3).

Description

Female.—Length 0.89-1.20 mm.

Male.—Length of only known specimen 0.92 mm. P5 (Fig. 224) redrawn from specimen of Grice and Hulsemann (1967), sample 42 (Table 3).

Remarks

Only about a dozen specimens of *Teneriforma naso* are known. Farran's (1936) only specimen had apparently lost the outer spine of P1 Re2, which is present on this species. He also failed to note the small outer seta of P2 Ri2 and the 2 small outer setae of P4 Ri3.

Grice and Hulsemann (1965) reported two females; lengths 0.9 and 1.1 mm (1966, unpublished station list).

Distribution

Pacific Ocean
  Southwest: Farran (1936), 0-600 m.
Indian Ocean
  West: Grice and Hulsemann (1967), 750-3,000 m.
Atlantic Ocean
  Northeast: Grice and Hulsemann (1965), 180-3,000 m.
  West: Wheeler (1970), 2,000-4,000 m.
  Caribbean Sea: Park (1970), 505-1,900 m.

SUMMARY

Most copepods of the family Spinocalanidae are known to be widely distributed, and they often comprise a large proportion, or even a majority, of the copepods in deep samples. However, because these copepods are fragile and therefore difficult to study, published records and descriptions of them have generally been vague or misleading.

As a basis for a review of the Spinocalanidae, zooplankton samples were collected from Fletcher's Ice Island in the Canadian Basin of the central Arctic, in 1967-68. Both sexes of seven species of spinocalanids were identified and redescribed: *Spinocalanus longicornis, S. antarcticus, S. horridus, S. elongatus, S. polaris, Mimocalanus crassus,* and *M. sulcifrons.* The depth of greatest concentration varied for each species, but was always below 100 m. Two species were taken in relatively shallow water (80-100 m) and four only below 300 m, but all were found at least as deep as 2,500 m.

Spinocalanus horridus and *Mimocalanus crassus* are probably cosmopolitan. The other five Arctic spinocalanids, in spite of great vertical ranges, have more or less restricted geographic distributions, and one species, *S. elongatus,* appears to be endemic to the Arctic. These restricted distributions may result from interactions with closely related species with similar vertical distributions. *Spinocalanus longicornis, S. antarcticus,* and *S. elongatus* appear to be replaced geographically by the closely related species *S. abyssalis, S. magnus,* and *S. brevicaudatus,* respectively. Of these species-pairs only *S. longicornis* and *S. abyssalis* are known to have substantial overlapping distributions. The distributions of all spinocalanids in the Arctic/North Atlantic transition area need further study.

All published records and descriptions of spinocalanids are reviewed. Type specimens of the following species have been examined and redescribed: *Spinocalanus abruptus, S. abyssalis, S. aspinosus, S. brevicaudatus, S. hoplites, S. longicornis, S. neospinosus, S. oligospinosus, S. ovalis, S. parabyssalis, S. pteronus, S. usitatus, S. ventriosus, Mimocalanus crassus, M. nudus,* and *M. sulcifrons.* Other critical specimens are redescribed, including four species identified by Farran as *Spinocalanus abyssalis* var. *pygmaeus, S. magnus* (two species), and *S. spinosus.* Many named species or forms are placed in synonymy, and two new species, *Spinocalanus terranovae* and *Mimocalanus heronae* are described. *Spinocalanus ovalis* is transferred to the genus *Mimocalanus*; *Spinocalanus longipes* is shown to be the male of *S. angusticeps*; males of *S. abyssalis* and *S. polaris* are considered to be incorrectly identified in the literature; and the male of *Mimocalanus nudus* and the female of *M. sulcifrons* are described for the first time.

The 32 species of Spinocalanidae which are considered valid are distributed as follows: *Spinocalanus* (19 species, in 3 groups containing 14, 4, and 1 species, respectively), *Monacilla* (4 species), *Mimocalanus* (8 species), and *Teneriforma* (1 species). Species of spinocalanids are most easily identified by certain

characters of the swimming legs. Since these legs are missing from most specimens, characters of the swimming legs have been correlated with other, relatively stable, characters, especially the armature of Mxp and body form and size. Characters used in the keys to genera and species have been selected so that usually even damaged specimens without swimming legs can be identified.

Males of most *Spinocalanus* species are left-handed, but males of *S. polaris* and *S. similis* are right-handed; the handedness is reflected not only in P5 but also in A1. Known males in other genera of Spinocalanidae are left-handed.

Within the Spinocalanidae, *Spinocalanus* and *Monacilla* appear to form one subgroup, while *Mimocalanus* and *Teneriforma* comprise a second subgroup. However, most appendages of *Monacilla* and *Teneriforma* species are still undescribed.

Males are not yet known for most of a complex of species related to *Spinocalanus spinosus*: *S. aspinosus*, *S. hoplites*, *S. oligospinosus*, *S. spinosus*, and *S. usitatus*. Undoubtedly, knowledge of these males will help clarify the relationships of the females, which are very similar to one another.

Males are also unknown for *S. abruptus* and *S. hirtus*; *Monacilla tenera* and *M. gracilis*; *Mimocalanus cultrifer*, *M. inflatus*, *M. major*, and *M. ovalis*. The female of *Monacilla* sp. is unknown.

Males of *S. terranovae*, *Monacilla* sp., and *Mimocalanus heronae* are each known only from one briefly described specimen. More specimens of *S. abruptus*, *S. hirtus*, *Monacilla gracilis*, *Mimocalanus inflatus*, *M. major*, and *M. ovalis* should be examined to confirm or clarify the status of these species.

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